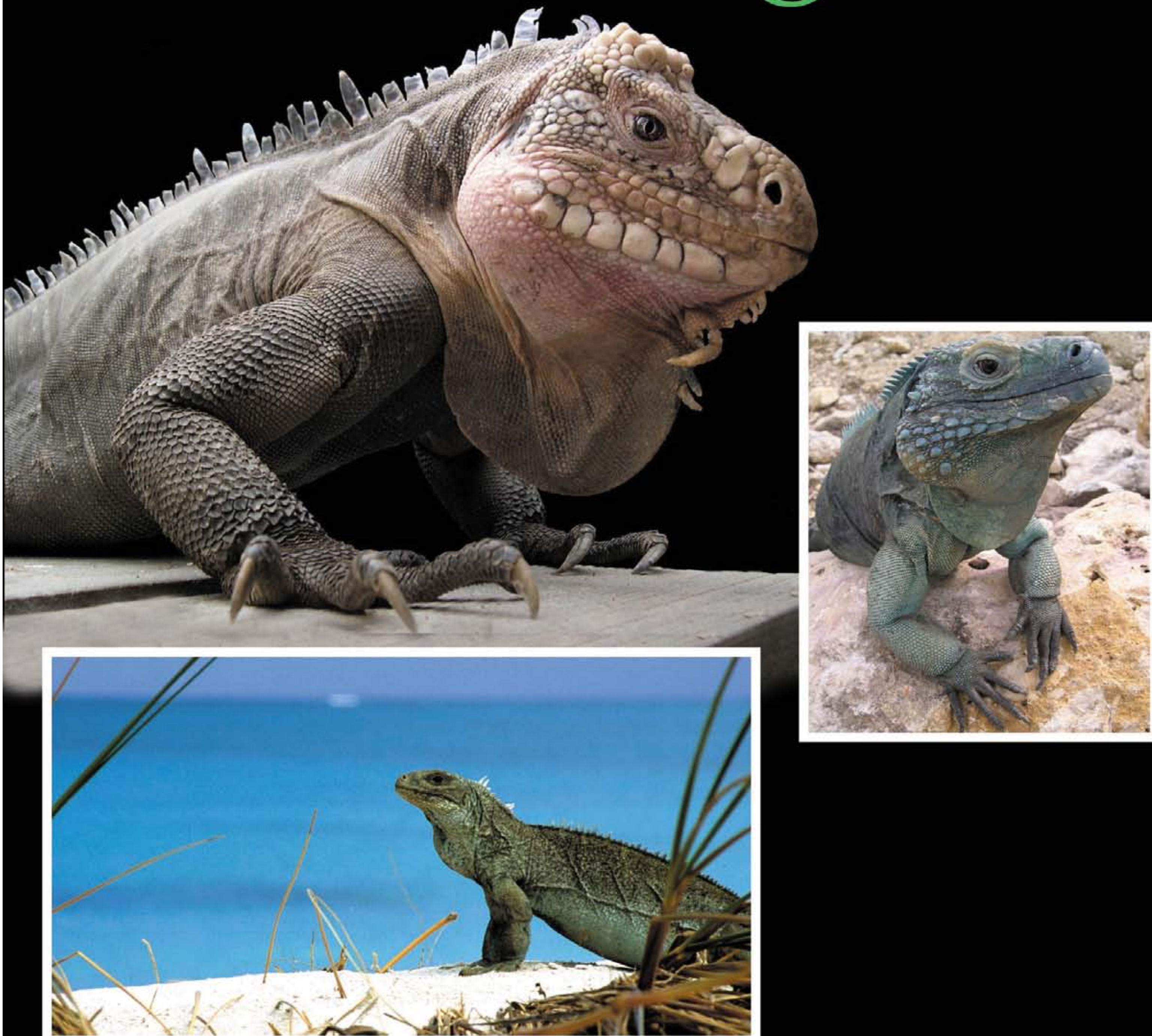
Husbandry Manual for West Indian Iguanas



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Introduction

The West Indian iguanas are a unique group of large, herbivorous lizards that inhabit tropical dry forests throughout the Bahamas and Greater and Lesser Antilles. The group consists of two genera: the rock iguanas (*Cyclura*) and the Lesser Antillean and green iguanas (*Iguana*). West Indian iguanas are among the most endangered lizards in the world, primarily because much of the tropical dry forest they inhabit has been eliminated by human development or severely degraded by exotic species. Feral predators such as mongooses, cats, and dogs prey heavily on juvenile iguanas, and on many islands, introduced livestock have denuded the vegetation on which iguanas depend. Until the arrival of man and domestic livestock, iguanas were the largest native land animals on these islands. Because they are potentially important seed dispersers (Iverson 1985, Hartley *et al*., 2000), the disappearance of West Indian iguanas could have severe negative impacts on the island ecosystems where they live.

With the formation of the IUCN/SSC Iguana Specialist Group in 1997, a group comprising many AZA institutions, conservation priorities have been established for this group of lizards. Field research continues with most taxa, and breeding programs have been developed for some of the more critically endangered taxa. *In situ* headstart facilities have been constructed for those taxa for which juvenile survival is severely impacted by introduced predators, and facilities are currently raising hatchlings for release on Grand Cayman, Anegada, Mona, Jamaica, and the Dominican Republic. Several other facilities are being planned on other islands. Because so many West Indian iguanas are now kept in breeding facilities both *in situ* and *ex situ*, there is a need to develop standard protocols for appropriate husbandry. Other than a few species-specific requirements, most *Cyclura* can be kept in similar fashion with success, whereas *Iguana delicatissima* has its own set of husbandry needs.

The following information has been compiled from our work with iguanids, both wild and captive, at the San Diego Zoo Institute for Conservation Research (formerly known as CRES) and Fort Worth Zoo. In addition, 14 institutions (private and public) submitted in-depth surveys on husbandry protocols for the various species held in captivity. Participating facilities include: Ardastra Gardens (Nassau, Bahamas); Blue Iguana Conservation Programme/National Trust for the Cayman Islands (Grand Cayman, Cayman Islands); Durrell Wildlife Preservation Trust (Jersey, Channel Islands, U.K.); El Paso Zoo (El Paso, Texas); Finca Cyclura (Robert Ehrig – Big Pine Key, Florida, USA); Indianapolis Zoo (Indianapolis, Indiana, USA); International Reptile Conservation Foundation, Inc. (John and Sandy Binns - San Jose, California, USA); Lincoln Park Zoo (Chicago, Illinois, USA); Miami MetroZoo (Miami, Florida, USA); St. Catherine's

Wildlife Survival Center (Wildlife Conservation Society - Midway, Georgia, USA); Sedgwick County Zoo (Wichita, Kansas, USA); and Tulsa Zoological Park (Tulsa, Oklahoma, USA).

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Natural History

Although the natural history of most West Indian iguanas is similar in many respects, slight differences may affect some captive parameters. For that reason, this section provides brief taxon-specific descriptions and notes that might be important to captive husbandry and reproduction.

Turks and Caicos iguana (*Cyclura carinata carinata*)

Male Turks and Caicos iguana (*Cyclura carinata carinata*)

Geographic range: Turks and Caicos Islands, British West Indies.
Adult size: males up to 36.0 cm SVL and 1.86 kg; females up to 29.0 cm SVL and 1.14 kg. Up to 77.0 cm total length.
Dietary notes: primarily herbivorous, but will take insects, mollusks, crustaceans, arachnids, lizards (including their own young), and carrion.
Size/age at sexual maturity: males reach maturity in about 7 years or 22.0 cm SVL and 0.33-0.48 kg; females at 6-7 years or 18.5 cm SVL and 0.20-0.30 kg.
Time of mating: April and May.
Time of oviposition: May and June.
Nesting parameters: nests in sand burrows.
Number of eggs: up to 11 (avg. 5).
Temperature/duration of incubation: 28-29#C (82.4-84.2 °F)/about 80-90 days
Egg size: average 51.8 x 31.1 mm; 25.9 g.
Hatchling size: average 8.0 cm SVL and 14.6 g.
Growth rates: juveniles: 20 mm/yr until maturity. Adults: 0.2-1.7 cm/yr.
References: Gerber and Iverson 2000, Iverson 1979, J. Lemm, pers. obs.

Bartsch’s iguana (*Cyclura carinata bartschi*)
NOTE: Recent molecular work by Catherine Stephen suggests *C. c. bartschi* is the same taxon as *C. c. carinata.

Bartsch’s iguana (*Cyclura carinata bartschi*)
Photo by J. Burgess

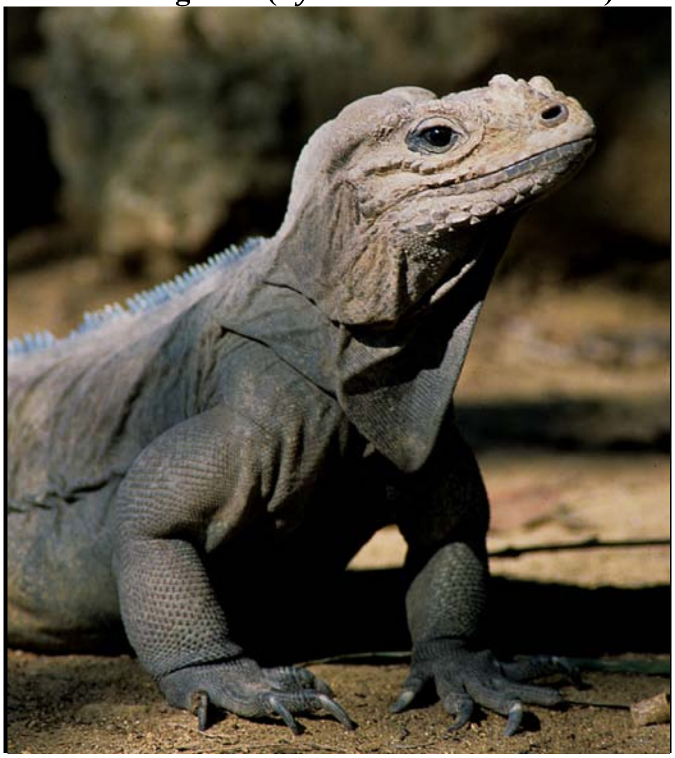
Geographic range: Booby Cay, Bahamas.
Adult size: males up to 37.5 cm SVL and 1.89 kg; females up to 28.8 cm SVL and 1.50 kg. Up to 77.0 cm total length.
Dietary notes: primarily herbivorous, but insects, mollusks, crustaceans, arachnids, lizards, and carrion are occasionally consumed.
Size/age at sexual maturity: unknown, but probably similar to *C. c. carinata*.
Time of mating: probably May.
Time of oviposition: probably June.
Nesting parameters: nests in sand burrows, often under vegetation.
Number of eggs: unknown.
Temperature/duration of incubation: unknown.
Egg size: unknown.
Hatchling size: smallest measured to date was 8.4 cm; a hatchling was captured roughly six months after hatching and measured 10 cm SVL; mass was 39.0 g.
Growth rates: unknown, but probably similar to *C. c. carinata*.
References: J. Bendon pers. comm., Buckner and Blair 2000a, S. Conners pers. comm., Schwartz and Carey 1977.

Jamaican iguana (*Cyclura collei*)

Male Jamaican iguana (*Cyclura collei*)

Geographic range: Hellshire Hills region of southeastern Jamaica.
Adult size: males up to 42.8 cm SVL; females up to 37.8 cm SVL.
Dietary notes: primarily herbivorous, but takes some animal matter, including snails. Juveniles are known to prey on beetles and spiders.
Size/age at sexual maturity: repatriated females have produced offspring at seven years of age. Mean size of reproductive females is 38.9 cm SVL and 2270 g.
Time of mating: May.
Time of oviposition: June.
Nesting parameters: nesting occurs in underground tunnel systems of burrows filled with loose soil. Communal nesting occurs. Tunnels range from 20-60 cm in length; some then turn 90° and continue at the same depth for another 30 cm. Depth has been recorded at 50 cm.
Number of eggs: up to 20.
Temperature/duration of incubation: 30 °C (86 °F)/85-87 days.
Egg size: average 55.8 x 38.9 mm; 39.9 g.
Hatchling size: average 9.5 cm SVL and 34.2 g.
Growth rates: unknown.
References: Vogel 1994, 2000; Wilson et al. 2004; van Veen pers. comm..

Rhinoceros iguana (*Cyclura cornuta cornuta*)



Adult female Rhinocerous iguana (*Cylura cornuta cornuta*)

Geographic range: Hispaniola.
Adult size: males up to 56.0 cm SVL and 10 kg; females up to 51.0 cm SVL.
Dietary notes: primarily herbivorous, but will consume some animal matter, especially caterpillars and pupae.
Size/age at sexual maturity: females probably become mature at 2-3 years.
Time of mating: May.
Time of oviposition: June.
Nesting parameters: burrow in soil; tunnel approximately one meter long with a chamber at the end just large enough for the female to turn around.
Number of eggs: up to 34 (avg. 17.4).
Temperature/duration of incubation: 31 °C (87.8 °F)/approximately 85 days
Egg size: 82.6 mm x 50.8 mm; 75-80 g.
Hatchling size: average 10.4 cm SVL and 51 g.
Growth rates: unknown.
References: Ottenwalder 2000a; Schwartz and Henderson 1991; Boylan 1984, 1985.

***Navassa Island iguana (*Cyclura cornuta onchiopsis*)**
***NOTE: Some authors classify *onchiopsis* as a full species based on meristic differences and isolation.**

Navassa Island iguana (*Cyclura cornuta onchiopsis*) specimen.
Photo by R. Powell

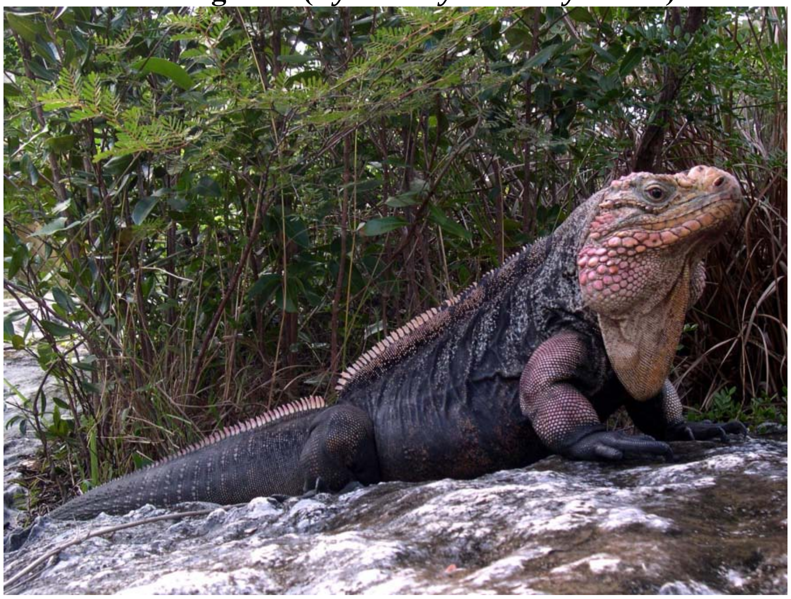
Geographic range: formerly Navassa Island.
Size: males up to 42.0 cm SVL; females to 37.8 cm SVL.
Notes: presumed to be extinct. Extirpation occurred during the late 19th Century, probably the result of exploitation by mine workers, combined with drastic alterations of habitat due to mining activities. The introduction of cats and goats to the island in the early 20th Century may have played a role in the extirpation of the iguana as well; however, no accounts after the 1860's mention iguanas.
References: Powell 2000, J. Binns pers. comm.

Mona Island iguana (*Cyclura cornuta stejnegeri*)

Mona Island iguana (*Cyclura cornuta stejnegeri*)

Geographic range: Mona Island.
Adult size: males average 51.7 cm SVL and 6.1 kg; females average 47.5 cm SVL and 4.7 kg.
Dietary notes: primarily herbivorous with some animal matter taken, especially caterpillars.
Size/age at sexual maturity: females reach maturity at 38.0 cm SVL and about 2.0 kg. They require approximately 6-7 years to reach this size.
Time of mating: June.
Time of oviposition: mid-summer (July).
Nesting parameters: nesting occurs in burrows in sandy clearings and sinkholes. Burrows measure up to 115 cm in length and up to 76 cm deep.
Number of eggs: average of 12.
Temperature/duration of incubation: 30-33 °C (86-91.4 °F) /approximately 83 days.
Egg size: 81.4 mm x 51.1 mm;107 g.
Hatchling size: average 11.9 cm SVL and 74 .0 g.
Growth rates: unknown.
References: Wiewandt 1977, Wiewandt and Garcia 2000.

Andros Island iguana (*Cyclura cychlura cychlura*)



Male Andros Island iguana (*Cyclura cychlura cychlura*)

Geographic range: Andros Islands, Bahamas.
Adult size: males up to 47.6 cm SVL; females up to 46.5 cm SVL.
Dietary notes: primarily herbivorous, although crabs are also consumed.
Size/age at sexual maturity: mean size of reproductive females is 36.2 SVL and 2,080 g.
Time of mating: not observed, but probably April.
Time of oviposition: early May to mid-June.
Nesting parameters: unknown, but where soil is limited, iguanas use termite mounds for nesting.
Number of eggs: 4-19 (avg. 8.8).
Temperature/duration of incubation: 32.8 °C (91.0 °F) in termitaria.
Egg size: average 70.7 mm x 40.3 mm; 59.8 g.
Hatchling size: average 9.6 cm SVL; 37 g.
Growth rates: unknown.
References: Buckner and Blair 2000b; Knapp 2001, 2002; Knapp et al. 1999, 2002; Schwartz and Henderson 1991.

Exuma Island iguana (*Cyclura cychlura figginsi*)

Male Andros Island iguana (*Cyclura cychlura cychlura*)
Photo by C. Knapp

Geographic range: Exuma Islands, Bahamas.
Adult size: males reach up to 54.2 cm SVL and 8.15 kg on some cays.
Dietary notes: primarily herbivorous; known to actively forage for the feces of birds.
Size/age at sexual maturity: mean size of reproductive females is 28.5 cm SVL and 960 g.
Time of mating: probably May.
Time of oviposition: probably June.
Nesting parameters: sand nest approximately 61 cm long and 8-13 cm deep.
Number of eggs: unknown; however, two wild nests each revealed only three eggs.
Temperature/duration of incubation: unknown.
Egg size: 85.0 mm x 40.0 mm; 51.0 g.
Hatchling size: unknown, but a small animal captured in late July measured 11.0 cm SVL and weighed 35.6 g.
Growth rates: unknown.
References: Coenen 1995, Knapp 2000.

Allen Cays iguana (*Cyclura cychlura inornata*)

Allen Cays iguana (*Cyclura cychlura inornata*)
Photo by J. Binns

Geographic range: northern Exuma Islands, Bahamas.
Adult size: males up to 47.6 cm SVL and 4.8 kg; females up to 36.8 cm SVL and 2.1 kg.
Dietary notes: primarily herbivorous and opportunistically carnivorous.
Size/age at sexual maturity: maturity is reached at 26-27 cm SVL, 750 g, and 12 years of age.
Time of mating: mid-May.
Time of oviposition: June-July.
Nesting parameters: nests in sand. Nest burrows average 149 cm in length and egg chambers usually angle off the main burrow. Depth of the egg chamber averages 28 cm and eggs are half-buried in the chamber.
Number of eggs: up to 10 (avg. 4.6).
Temperature/duration of incubation: 80-85 days at an average of 31.4 °C (88.5 °F).
Egg size: average 67.5 mm x 34.8 mm; 49.1 g.
Hatchling size: average 9.5 cm SVL and 33 g.
Growth rates: 20 mm SVL per year during the first year, declining to about 15 mm SVL per year by 5.5 years (206 mm SVL). Growth in females then slows, while it continues in males at the same rate until about 300 mm SVL.
References: Iverson 2000; Iverson et al. 2006, 2004a, 2004b; Knapp and Iverson (in press); Knapp et. al., 2006.

Grand Cayman Blue iguana (*Cyclura lewisi*)

Male Grand Cayman Blue iguana (*Cyclura lewisi*)

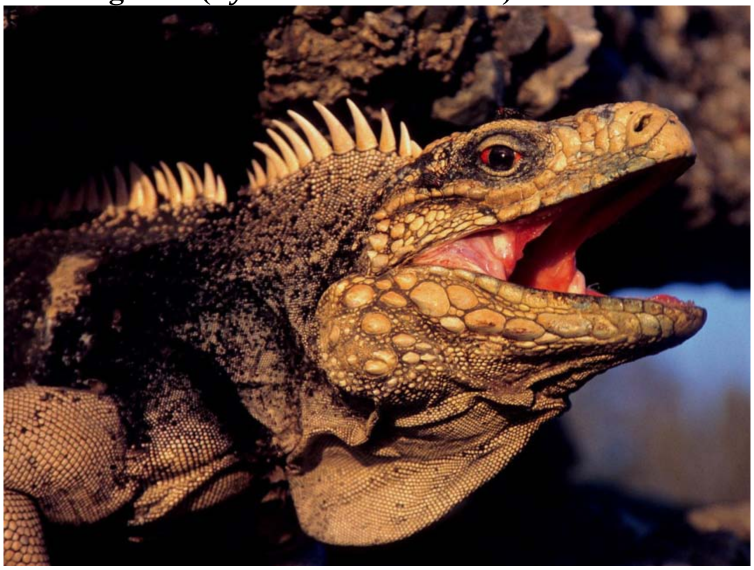
Geographic range: Grand Cayman.
Adult size: males to at least 10 kg body weight with evidence of larger individuals.
Dietary notes: primarily herbivorous, but coprophagy and soil ingestion, as well as rare insect feeding has been documented.
Size/age at sexual maturity: reached at approximately 20 cm SVL (2-3 years).
Time of mating: April-May (- early June).
Time of oviposition: June-July.
Nesting parameters: base of the nest chamber is usually 30 cm below surface; the access tunnel is closed with compacted soil and the earth around it smoothed to disguise it.
Number of eggs: up to 22.
Temperature/duration of incubation: 32 °C (89.6 °F)/66 to 80 days.
Egg size: average 48 mm x 68 mm; 85.0 g.
Hatchling size: average 9.7 cm SVL and 44.0 g.
Growth rates: usually pass 20 cm SVL threshold for reproductive maturity in 2-3 years, suggesting 3-5 cm SVL/year.
References: F. Burton and R. Goodman pers. comms.
Comment: recently elevated to full species status by Burton (2004).

Sister Isles rock iguana (*Cyclura nubila caymanensis*)

Adult female Sister Isles rock iguana (*Cyclura nubila caymanensis*)

Geographic range: Little Cayman and Cayman Brac, Cayman Islands.
Adult size: males up to 57.0 cm SVL and 8.5 kg; females up to 47.2 cm SVL and 5.2 kg.
Dietary notes: primarily herbivorous and often feed on carrion (crabs) and insects.
Size/age at sexual maturity: females are sexually mature by 30.8 cm SVL and two years of age.
Time of mating: April-May.
Time of oviposition: May-June.
Nesting parameters: nest in small patches of soil or in large sandy areas. The nest chamber is 10-50 cm deep.
Number of eggs: up to 25 (avg. 15).
Temperature/duration of incubation: unknown/63-80 days.
Egg size: unknown.
Hatchling size: average 10.7 cm SVL and 50.0 g.
Growth rates: juveniles grow an average of 100 mm SVL per year during their first two years.
References: Gerber 2000.

Cuban iguana (*Cyclura nubila nubila*)



Adult male Cuban iguana (*Cyclura nubila nubila*)

Geographic range: offshore cays of Cuba and in isolated protected areas on the mainland; an introduced population exists on Isla Magueyes, Puerto Rico.
Adult size: males average 40.5 cm SVL and may grow to over 8.0 kg in mass. Females average 32.0 cm SVL.
Dietary notes: primarily herbivorous, but also feeds on crabs and carrion.
Size/age at sexual maturity: 2-4 years; smallest females to lay measured 300 mm SVL and weighed 1.6 kg.
Time of mating: May.
Time of oviposition: June.
Nesting parameters: nests in soil or sand, often under objects such as rocks or plants. On Isla Magueyes, mean tunnel length is 153 cm with one or two turns; average chamber depth is 43 cm.
Number of eggs: up to 30 (avg 8.6).
Temperature/duration of incubation: 31-32 °C (88.5-89.6 °F)/approximately 70-78 days on Isla Magueyes.
Egg size: average 43.5 mm x 32.1 mm; 75.2 g.
Hatchling size: average 9.9 cm SVL and 48.2 g.
Growth rates: 8.37 mm SVL/month from 6-22 months.
References: Alberts et al. 1997, 2004; Christian 1986; Christian and Lawrence 1991; Perera 2000; J. Lemm pers. obs.

Anegada Island iguana (*Cyclura pinguis*)

Adult male Anegada Island iguana (*Cyclura pinguis*)

Geographic range: Anegada, Guana, Necker, and Norman Islands, British Virgin Islands.
Adult size: the largest reported male was 54.4 cm SVL and 7.2 kg, although recent studies found that males average 45.0 cm SVL and 4.0 kg; females average 41.3 cm SVL and 2.9 kg.
Dietary notes: primarily herbivorous, but opportunistically feed on insects and crabs.
Size/age at sexual maturity: smallest wild female known to lay viable eggs measured 37.8 cm SVL and weighed 2.08 kg. Maturity probably occurs at 4-7 years of age.
Time of mating: May.
Time of oviposition: June.
Nesting parameters: nesting occurs in sand with tunnels up to 320 cm in length and up to 90 cm deep. Nest chambers average 52 cm long by 29 cm wide and 14 cm high. Eggs are half-buried in loose sand with an air space above that is roughly half the height of the nest chamber.
Number of eggs: up to 17 (avg. 11.4).
Temperature/duration of incubation: nests average 30.4-31.0 °C (86.7-87.8 °F); average incubation is 92 days.
Egg size: average 64.8 mm x 45.0 mm; 62.7 g.
Hatchling size: 10.1 cm SVL and 47.0 g.
Growth rates: average of 4.14 mm SVL per month for captive juveniles.
References: Gerber 2000, J. Lemm pers. obs.

Ricord's iguana (*Cyclura ricordii*)

Adult male Ricord's iguana (*Cyclura ricordii*)

Geographic range: southwestern Dominican Republic and Southeastern Haiti.
Adult size: males up to 49.5 cm SVL; females up to 43.0 cm SVL.
Dietary notes: primarily herbivorous.
Size/age at sexual maturity: 2-3 years of age.
Time of mating: May.
Time of oviposition: first rainy period in May or June.
Nesting parameters: nests in fine, sandy soils; egg chamber depth about 40 cm.
Number of eggs: up to 18.
Temperature/duration of incubation: 30-31 °C (86-87.7 °F)/95-100 days.
Egg size: unknown.
Hatchling size: 8.74 cm SVL and 30.0 g.
Growth rates: unknown.
References: Ottenwalder 2000b.

San Salvador iguana (*Cyclura rileyi rileyi*)

San Salvador iguana (*Cyclura rileyi rileyi*)
Photo by J. Binns

Geographic range: San Salvador and nearby cays, Bahamas.
Adult size: up to 39.5 cm SVL; 89.0 cm TL.
Dietary notes: primarily herbivorous.
Size/age at sexual maturity: females are sexually mature at 21.5 cm SVL and 340 g.
Time of mating: May and June.
Time of oviposition: July.
Nesting parameters: nests in sandy soil in burrows 30-116 cm in length; egg chamber 18-28 cm below surface.
Number of eggs: up to 6 (avg. 4.4).
Temperature/duration of incubation: unknown/91-92 days.
Egg size: 53.4 mm x 29.5 mm; 27.7 g.
Hatchling size: 21.5 g.
Growth rates: unknown.
References: Cyril et al. 2001, Hayes et al. 2004.

White Cay iguana (*Cyclura rileyi cristata*)

Adult White Cay iguana (*Cyclura rileyi cristata*)
Photo by Steve Conners

Geographic range: White (= Sandy) Cay, Southern Exumas, Bahamas.
Adult size: up to 28.0 cm SVL.
Dietary notes: primarily herbivorous.
Size/age at sexual maturity: unknown.
Time of mating: unknown, but probably May-June.
Time of oviposition: unknown, but probably June-July.
Nesting parameters: unknown.
Number of eggs: unknown.
Temperature/duration of incubation: unknown.
Egg size: unknown.
Hatchling size: unknown.
Growth rates: unknown.
References: Hayes 2000.

Acklin's iguana (*Cyclura rileyi nuchalis*)

Adult Acklin's iguana (*Cyclura rileyi nuchalis*)
Photo by W. Hayes

Geographic range: islands of Acklins Bight, Bahamas.
Adult size: unknown.
Dietary notes: primarily herbivorous; probably takes some animal matter.
Size/age at sexual maturity: females reach maturity at 19.5 cm SVL and 260 g.
Time of mating: unknown, but probably May-June.
Time of oviposition: unknown, but probably June-July.
Nesting parameters: nests in sand burrows 69-235 cm in length. Egg chamber is 14-40 cm deep.
Number of eggs: avg. 3.1.
Temperature/duration of incubation: 30 °C (86.0 °F).
Egg size: 55.5 mm x 30.2 mm; 27.1 g.
Hatchling size: unknown.
Growth rates: unknown.
References: Hayes et al. 2004, Thornton 2000.

Lesser Antillean iguana (*Iguana delicatissima*)

Male Lesser Antillean iguana (*Iguana delicatissima*)

Geographic range: Numerous islands in the Lesser Antilles.
Adult size: males up to 43.0 cm SVL and 3.5 kg; females up to 39.0 cm SVL and 2.6 kg.
Dietary notes: herbivorous, although has been observed feeding on animal matter.
Size/age at sexual maturity: On Chancel (an island with a population of iguanas that grows to a smaller maximum size than iguanas on other islands) females become mature at about three years and 240-250 mm SVL. Males become mature at 270-280 mm SVL (about five years).
Reproduction: varies by island; gravid females can be found on some islands from February to August.
Nesting parameters: nests are constructed in sandy, well-drained soils that are exposed to prolonged sunlight. Tunnels are 1 m long with an egg chamber large enough for the female to turn around. One clutch was found at a depth of 100 mm.
Number of eggs: up to 27.
Temperature/duration of incubation: 30 °C (86.0 °F)(+/- 2-3 °C) for about three months (+/- one week).
Egg size: average 45.0 mm x 25.0 mm; 17-22 g.
Hatchling size: a single wild hatchling measured 67 mm SVL and weighed 15.0 g.
Growth rates: males 230-260 mm SVL grew an average of 55 mm SVL and 650 g in three years. Females 250-300 mm SVL grew an average of 21.6 mm SVL and 150 g in 3.3 years.
References: Breuil pers. comm. 2002, Day et al. 2000, Schwartz and Henderson 1991.

Captive Management

By Jeffrey M. Lemm

Population Management

By Tandora Grant

A studbook database has been maintained for all *Cyclura* species held in AZA institutions since 1995. In cooperation with zoo registrars, a lengthy history of captivity was reconstructed and contains a record of over 1500 animals among 50+ institutions from 1898 to present. A few private non-zoo reptile breeders have also contributed information to the studbook, especially for animals that have a zoo history. In addition, *Cyclura* raised for headstarting and release in Anegada, Jamaica, Grand Cayman, and Dominican Republic are included in the studbook. The rhinoceros iguana (*C. c. cornuta*) and the Cuban iguana (*C. n. nubila*) have historically been the most abundant among U.S. and international zoos. Currently, there is also a small number of Jamaican (*C. collei*), Grand Cayman (*C. lewisi*), Sister Isles (*C. n. caymanensis*), Exuma Island (*C. c. figginsi*), and Anegada Island (*C. pinguis*) iguanas living in U.S. institutions. There are also three institutions in the US and Europe that house *Iguana delicatissima*, though they are not included in the *Cyclura* studbook.

Small Population Animal Record Keeping System (SPARKS), the studbook software, catalogs animal life spans, growth data, medical and reproductive history, facility transfers, and ancestry. In conjunction with population management software (PM2000), the data contained in the *Cyclura* studbook are analyzed genetically and demographically, to create a profile of the captive population that will assist with its management. This includes information on the number of founders, the distribution of their genes among living animals,the relationships among individuals in the living population, the capacity of the population to retain genetic variation, age and sex structure of the population, age-specific survivorship and fertility rates, and generation length. Results of these analyses are used to arrive at a carrying capacity for the captive population and formulate recommendations for managing it at this size. The timeliness and accuracy of data reported to the studbook by animal care staff is critical to the success of this program.

The AZA Rock Iguana Species Survival Plan (SSP) was approved in April 1996. Though all nine species (16 taxa) comprising this genus are threatened, for the immediate future the SSP has focused on three of the most critically endangered; the Jamaican iguana, the Grand Cayman Blue iguana, and the Anegada Island iguana. The goals of the SSP are to manage captive populations of these species as a hedge against extinction in nature, and to utilize these zoo-based programs to generate support for ongoing *in situ* conservation, research, and recovery programs. Nineteen AZA zoos and aquariums have signed a memorandum of understanding for this SSP, and over 20 have contributed funds to support conservation initiatives for most of the taxa, including all those ranked as critically endangered. At least nine Rock Iguana SSP institutions are directly participating with iguana field research and conservation initiatives in eight Caribbean countries.

In accordance with the conservation goals of the SSP and the Iguana Specialist Group, a Population Management Plan for the Grand Cayman Blue iguana has been initiated. The AZA population manager and SSP coordinator work closely with the National Trust for the Cayman Islands and U.S. zoos to make breeding recommendations which maximize potential by considering both populations as a single entity. In order to maintain long-term viability, the management plan recommends increasing the number of founders to 20, increasing the captive population size to 225 animals, extending the number of years before founder dilution, and equalizing founder representation among animals in the U.S. and Grand Cayman. Breeding recommendations for the Grand Cayman facility also provide genetically diverse progeny for release into protected areas to prevent wild extinction of this species.

The Grand Cayman Blue iguana is one species for which a Population Management Plan (PMP) has been initiated.

Population management plans for Anegada Island and Jamaican iguanas, similar to that for the Grand Cayman Blue iguana, will follow when breeding success improves.

Quarantine

In order to reduce the spread of parasites and other ailments in captive facilities, animals new to a facility should be quarantined for 30-90 days in separate holding areas. Physical examinations, blood work, and at least three fecal samples that test negative for endoparasites are typically required at most facilities prior to a new animal joining other collection animals. Quarantine is also the best time to implant a passive integrated transponder (PIT) tag for identification purposes if the new animal does not yet have one. The Central Florida Zoo is perhaps the most thorough with respect to reptile quarantine protocols and is a recommended model for quarantine procedures. Their animals are subject to a 90-day quarantine, physical examination, weekly weighing, CBC, plasma biochemical panel, frozen (banked) plasma sample, blood culture, fecal examination, and cloacal culture for aerobic bacteria. If an animal is positive on either blood culture or if abnormalities are detected in the physical exam, CBC, or chemistry panel, a whole body radiograph and/or ultrasound is completed. Before release from quarantine, animals receive a repeat physical examination, blood culture, CBC, chemistry panel, and weighing.

Housing

Because most West Indian iguanas occupy large areas in the wild, spacious enclosures are necessary for their captive care. Pairs should be kept in enclosures at least 10 ft x 6 ft x 6 ft (3 m x 1.8 m x 1.8 m), but larger areas (minimum of 12 ft x 12 ft x 10 ft = 3.6 m x 3.0 m x 3.6 m) are ideal. Adult males should never be housed together as they will almost always fight, leading to severe injuries. Climbing is important for iguanas of all ages and cage height should be adjusted so that keepers can comfortably work and access lizards. At ICR, we have found that cage heights of 8-10 ft (2.4-3.0 m) are easy to access and allow lizards to maintain a comfortable level of security. Climbing structures such as large logs and shelves are also useful, for both juvenile and adult iguanas. Hide areas are also necessary in maintaining West Indian iguanas. At ICR, heated hide areas are made available by equipping plastic doghouses (Dogloo®, Petmate, Arlington, TX) with 250-watt Pearlco (Ram Network, Reseda, CA) ceramic heat bulbs in 500-watt Smith-Victor light hoods (Griffith, IN). The entrance to the dogloo is then covered with a sheet of pliable vinyl with a slit cut down the middle from top to bottom. The vinyl sheet holds in the heat and the slit works as a door for the iguanas. In general, the ceramic bulb should be placed on a thermostat as these bulbs, especially new ones, can heat the area inside the house to extreme temperatures. Additional retreats, visual barriers, and hides such as PVC tubes, concrete blocks, large rocks, plants, wood shelters, logs, ice chests, and a variety of other retreats have been used by many institutions with success. Plants provide excellent cover and browse. Native West Indian plants such as sea grape provide cover and are durable because the animals do not normally feed on the leaves. Readily available nursery plants such as *Ficus* and *Hibiscus* can withstand enclosure temperatures and provide cover, but adult iguanas will denude the leaves so quickly (even with daily feedings) that plants may need to be rotated in and out of enclosures every week or two. The most ideal, readily available plants in the U.S. that provide sufficient cover and sight barriers are species such as palms and cacti on which iguanas rarely browse in captivity.

Adult male iguanas should never be housed together. Fights will usually occur leading to severe injuries. This is a pair of *C. c. cornuta* in combat.

Enclosures should be designed so animals can be separated if needed. Two smaller enclosures with an access door attaching the two enclosures have proven useful at some facilities. In headstart facilities, smaller animals may become stressed near larger animals or may be constantly harassed by them. Smaller animals should be moved into cages with smaller conspecifics or by themselves. Animals that are thin, show small injuries and scrapes on the neck, side, or feet, or constantly hide, are candidates for cage moves in group situations. Injured or sick animals should always be housed by themselves, and when being re-introduced to a cage with one or more animals should always be monitored, as resident iguanas may not welcome them back. Off-display enclosures and headstart facilities are often made of pressure-treated lumber frames or galvanized steel frames covered with half-inch by one-inch mesh. Mesh works well for smaller animals, but larger animals often catch toes or tear out nails in enclosures made of smaller meshes. Ideally, the largest mesh that will prevent animal escape and intrusion by snake predators or rats and mice should be used. Mesh-covered walls should have a strip of plastic or wood at the base to keep animals from rubbing their noses or fighting with neighboring animals. Smooth walls are ideal for both display and off-display enclosures. Smooth concrete walls (at least four ft high on the inside of the enclosure) work well in outdoor display areas, and concrete, glass, and/or plastic materials (PVC sheets) can be used for indoor exhibits. For outdoor off-display areas, a combination of low wall and mesh is both inexpensive and practical.

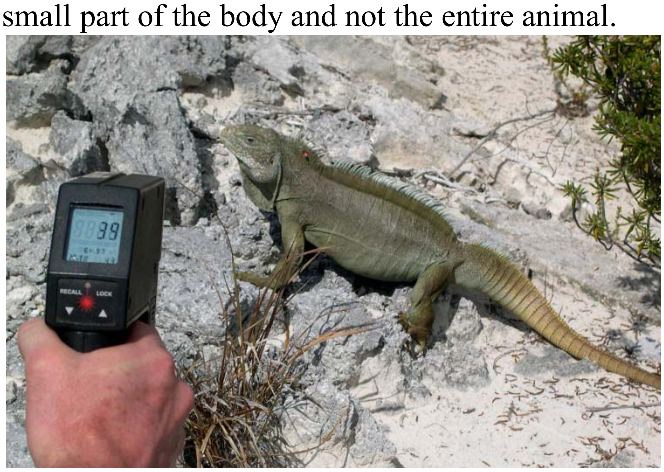
Digging barriers should be placed under the enclosure substrate to prevent escape via burrowing. An ideal substrate depth is 3-4 ft of soil or sandy soil that will maintain humidity and burrow integrity. Some institutions use pea gravel or decomposed granite, and this works well; however, animals can construct more suitable burrows in dirt. In addition, some facilities report intestinal impactions from pea gravel, decomposed granite, and sand. Humidity levels of 50-80% are ideal for keeping most iguanas and can be maintained throughout the year by lightly spraying enclosures with water and keeping plants and planters moist. Water should be provided at all times and cages should be cleaned daily, being careful to remove all feces, especially near feeding areas.

Indoor *C. collei* enclosure at CRES, San Diego Zoo. The square box in the rear corner is used for nesting and contains three feet of soil.

Ultraviolet light is necessary for processing vitamin D_3 and for proper bone mineralization. Indoor/outdoor enclosures are useful in this regard, allowing animals to receive natural, unfiltered light for at least part of the year. In colder regions, UV-transmitting plastics and glass can be used for skylights. ICR and other facilities are using Solacryl SUVT™ panels (Polycast Technology Corp., Stamford, CT) that have approximately 85% UVB transmission. Recently, however, it was discovered that Solacryl may be similar to UVB bulbs in that animals have to be in close proximity to the material to access usable UVB (J. Lemm, pers. obs.). A UV-transmitting plastic called Acrylite OP-4 is being used by some facilities with success (CYROIndustries, Rockaway, New Jersey). Active UV Heat, once known as the Westron Dragonlite (T-Rex products, Inc. Chula Vista, CA), has proven to raise circulating D_3 levels in Komodo dragons to that of wild counterparts when suspended 200 cm above animals (Gillespie et al., 2000). Many facilities that house *Cyclura* are now using these bulbs, while others are using different mercury vapor lamps and/or fluorescent bulbs. Unfortunately some of these bulbs degrade very quickly and often lack UVB right out of the box! A new bulb on the market, made by MegaRayUV (www.reptileuv.com), is said to provide very large amounts of UVB light and supposedly lasts for more than a year.

West Indian iguanas require thermal gradients and high basking temperatures. Ambient enclosure temperatures should not drop below 65 °F (18.3 °C) at night and should not rise above 90 °F (32.2 °C) during the day. Optimal ambient temperatures should be maintained at roughly 85 °F (29.4 °C), with cooler areas for the animals to retreat. During winter, ambient temperatures can be lowered 5 - 7 °F (2.8 - 3.9 °C).

Basking areas with high temperatures should be maintained throughout the year. Wild animals typically maintain body temperatures of 96.8 - 105.8 °F (36 - 41 °C) throughout the day (Alberts et al. 2004; G. Gerber pers. comm; J. Lemm pers. obs.). Captive specimens often bask at surface temperatures as high as 150 °F (65.5 °C). It is interesting to note that the facilities with the most successful breeding programs utilize high temperature basking. These high temperatures can be safely provided using spotlight or floodlight-type heaters, as well as infrared brooders. Injuries such as thermal burns have never been recorded when following these heating protocols (J. Lemm, pers. obs.). High-temperature contact heaters, such as pig blankets, hot rocks, and heating pads are not normally recommended for diurnal basking lizards, but some facilities use them without incident. Heat tape may be used in conjunction with some nighttime retreats such as PVC tubing. It is believed that most burns occur when ambient conditions are cool or cold and a cold animal is allowed to bask by sitting on a hot heat source, or when an animal is allowed to approach a basking source too closely, such that it is focused on a small part of the body and not the entire animal.



Non-contact thermometer reading of a wild *C. c. carinata* in the early morning. The surface temperature of this basking iguana reads 39 °C (102.2 °F).

Near the time of publication of this manuscript, the ICR iguanas moved into a new facility at the San Diego Zoo's Wild Animal Park. The 2,000 square foot Kenneth C. and Anne D. Griffin Reptile Conservation Center was built specifically for the husbandry and breeding of *Cyclura*. It consists of 20 indoor/outdoor enclosures,a kitchen, and a nursery. The building is temperature-controlled with a heating and air-conditioning unit and humidity is maintained through a system that injects mist directly into the air handlers. Each enclosure has a soil depth of three feet in both the indoor and outdoor areas. The indoor and outdoor sections are separated by a solid wall and animals use a guillotine door to access the outside enclosure. Guillotine doors are also utilized between cages to introduce animals during the breeding season. Each enclosure is planted with native Caribbean plants, and the indoor sections are equipped with a basking area utilizing Active UV heat bulbs and natural sun filtered through Acrylite OP-4 skylights.

The new Griffin Reptile Conservation Center at the San Diego Zoo Institute for Conservation Research (ICR). Animals from the old CRES enclosures (San Diego Zoo) were moved to the Griffin Center at the San Diego Zoo's Wild Animal Park in 2009.

Foundation of Griffin Reptile Conservation Center showing individual cages and depth of each indoor/outdoor enclosure.

Iguana enclosure at Griffin Reptile Conservation Center showing indoor-outdoor cages planted with native Caribbean plants and palms.

Corridor down the center of the 20 iguana enclosures at the Griffin Reptile Conservation Center.

AZA minimum caging standards for a single *Cyclura* is 6 ft x 6 ft x 6 ft (1.8 m x 1.8 m x 1.8 m). Animals need to have access to separate caging, fresh water, indoor, heated hide areas, at least two feet of soil for burrowing and nesting, and access to ultraviolet light (either natural or electric). Fresh food is to be provided daily (minimum of five times per week), and basking areas are a necessity.

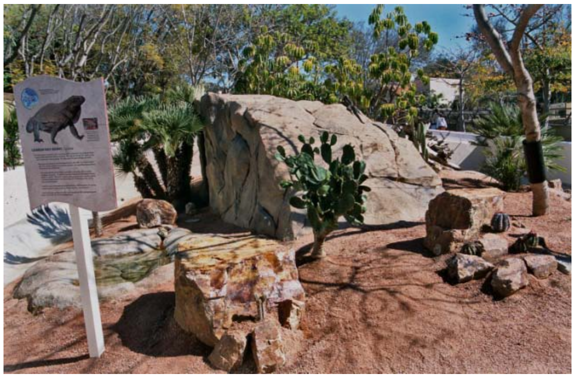
C. c. cornuta enclosure at the El Paso Zoo
Photo by Amanda Leverett

The Reptile Greenhouse is part of the Fort Worth Zoo's Animal Outreach & Conservation Center (ARCC) and is designed to support breeding groups of endangered rock iguanas (*Cyclura*) and Asian chelonian species. Photo by Rick Hudson

Five outdoor iguana yards with adjacent inside holding areas are featured at the Fort Worth ARCC facility. Species targeted for captive breeding include the Jamaican and Anegada iguanas.
Photos by Rick Hudson.

Above view of indoor and outdoor iguana enclosures at San Diego Zoo.

Outdoor *C. pinguis* enclosures at San Diego Zoo.

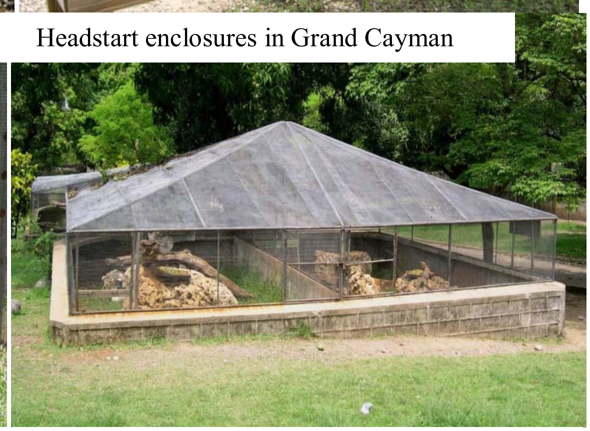


Display enclosures for *C. collei* and *C. pinguis* at the San Diego Zoo

Breeding enclosures in Grand Cayman

Headstart enclosures in Grand Cayman

C. collei headstart facility at the Hope Zoo in Kingston, Jamaica



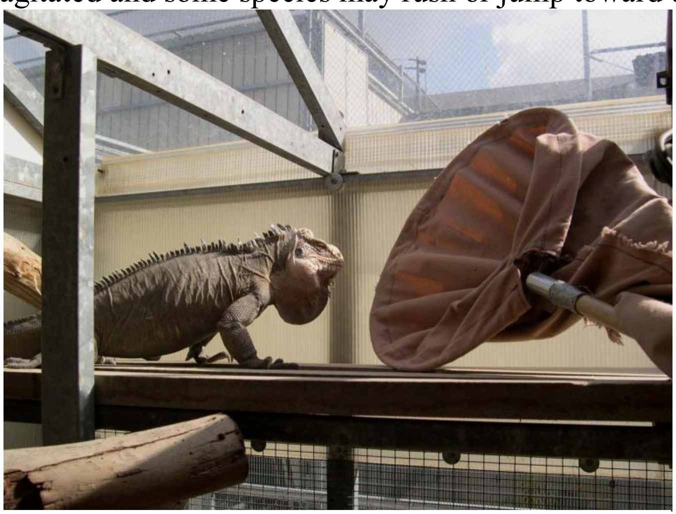
C. collei exhibit at the Hope Zoo in Kingston, Jamaica

Proper Animal Capture, Restraint, and Handling

In order to reduce the risk of injury to both animals and keeper, proper restraint techniques are necessary whenever iguanas are handled. It should be noted that handling and restraint put a tremendous amount of stress on an animal and iguanas should only be handled when necessary (vet checks, weighing and measuring, moving to new enclosures). In addition, keepers should do everything possible to reduce stress on cagemates that are not being captured. For instance, iguanas hiding in tubes or other hide areas should not be disturbed. Instead, the entire hide area should be moved whenever possible. These same methods should be used with daily cage maintenance. Captive animals may show signs of stress immediately following capture. These signs, which may last a few days, generally include appetite loss, constant hiding, and flight behavior.

Because iguanas have strong jaws and large, powerful claws, minor injuries to keepers are common. Even juvenile iguanas can inflict nasty bite wounds that often require stitches, and a bite from an adult iguana can be serious. Iguana scratches are common, especially from the long rear toes of the rear legs. In addition, hatchling and juvenile iguanas may have their tails broken off due to improper handling techniques.

Perhaps the easiest, least-stressful way to capture an animal from within an enclosure is with a net. Large fishing nets, with the net replaced by a sturdy cloth bag, work well for this purpose. Netting rips easily and iguanas have the ability to break through the net and escape or they may become tangled in the netting. "Hand-grabbing" or manually capturing iguanas works well with younger animals, or larger, non-aggressive adults. Keep in mind that when cornered, some iguanas may become very agitated and some species may rush or jump toward the keeper with open mouths.



Nets are the easiest, least-stressful way to capture large iguanas, such as this *I. delicatissima*.

In some cases, large, tame iguanas can be handled without restraint for educational purposes and related activities. The easiest way to handle these individuals is by resting them on the forearm with the hand gently supporting the chest of the animal. The handler's second hand is used to support the rear of the body. If the animal should become agitated, the forward hand can easily be shifted to restrain the head of the animal while the handler's other hand can restrain the tail and/or rear legs. So-called "tame" animals can quickly become nervous or irritated outside of their normal quarters and handlers should always be aware of their surroundings and potential escape hazards.

Allison Alberts shows the correct way to handle large, "tame" iguanas for educational purposes.

Hatchling iguanas should be restrained in the middle of the body with the head secure. Larger juvenile and adult iguanas should be restrained with two hands. One hand should lightly yet firmly grasp the animal behind the head, either in the neck or shoulder region to prevent the animal from turning and biting. The second hand should be placed over the pelvic region, keeping a firm grasp on the rear legs to prevent scratches to the hand or arm that is restraining the head. The tail of the iguana is also a powerful weapon and can be restrained under the arm of the hand that is grasping the rear legs. In many cases it is easier to restrain the tail and one of the rear legs using the same hand. When possible, large iguanas should be restrained by two people, with one person holding the head and a second individual holding the hindquarters of the animal. During measurements of larger iguanas, some keepers and field researchers have found that blindfolds such as elastic knee bands placed over the entire head of the animal work well to calm the animal and keep it from attempting to bite. This technique will also help protect the person taking measurements as many species of iguana will keep the mouth agape during restraint and any hand movement near the mouth may result in a bite. In addition, many researchers simply turn an iguana over on its back, which generally quiets the animal significantly, even if it is highly agitated.

Two-person hold of a large iguana.

Proper handling of a juvenile iguana.

Reproduction and Nesting

With the exception of two species (*C. c. cornuta* and *C. n. nubila*), successful captive reproduction of West Indian iguanas has been limited. Many successful U.S. breedings involve animals that are paired annually or separated for brief periods. In addition, animals that have been raised together are much easier to pair than animals that are paired for the first time as adults. Captive iguanas vary in disposition and some species (i.e., *C. lewisi*) can be very aggressive toward conspecifics outside the breeding season. Most of the taxa kept in captivity can be raised together and later kept in pairs; however, after females lay, males often become aggressive towards them and may need to be separated. Wild animals vary in behavior towards one another as well. For example, some Cuban iguanas in the wild may be found together annually and even share retreats outside the breeding season (J. Lemm pers. obs.), whereas others are rarely found together outside the breeding season. For purposes of captive reproduction, most facilities agree that housing potential mates together for at least most of the year is advisable. It is also recommended that potential pairings be approved by the studbook keeper.

This pair of wild *C. n. nubila* shares the same burrow throughout the year. This photo was taken in the month of December, showing that some animals may develop pair bonds.

Pairs should be housed in large enclosures that can be divided during periods of aggression. For species such as *C. lewisi*, or individual animals that are aggressive towards mates during the non-breeding season, chemical and visual contact should be maintained when animals are not housed together. Plexiglass windows with holes drilled in them, or even small, plastic-coated screens between cage walls work well in maintaining contact between animals. This same type of contact can also be used between cages of adult males to stimulate breeding. When contact between males is desirable to stimulate breeding behavior but not logistically possible, placement of small mirrors within enclosures can be useful. In order to reproduce, female iguanas must have sufficient body weight. Weight gain and maintenance is usually not a problem when high basking temperatures and plenty of food are offered. A slight temperature drop combined with a reduction in light cycle for the late winter and spring often help to stimulate breeding when temperature and day length are subsequently increased. In most U.S. facilities, breeding takes place from April-July, depending on species and temperatures/light cycles. The majority of copulations occur around June, with oviposition in July. Copulation may appear to be somewhat rough in iguanas and females often bear small injuries to the nuchal crest. Over-aggressive males can injure females. If males prevent females from eating, constantly chase them, bite their crest so severely that it bleeds excessively or loses scales, the animals should be separated. For animals that are separated except during breeding, the first introductions can be dangerous for the female, and keepers should be ready to remove over-aggressive males. Males should always be placed in the cages of females for breeding to reduce the risk of a territorial assault on the female. Animals with a strong pair bond usually copulate without excessive roughness, feed and bask together, and males often protect females from keepers. Animals with this type of bond usually do not have to be separated during nesting, although females may become aggressive towards males at this time. In the rare event that females do not seem stressed by the male's presence and continue feeding until just before oviposition, the male should be allowed to stay in the enclosure. In most cases, males should be removed from the female's enclosure for nesting. With more and more instances of successful copulations in captivity, nesting is emerging as the primary roadblock to breeding West Indian iguanas. In many facilities, reports of successful copulations and fertile eggs are confounded by low hatching rates. It seems that even with fertile eggs, if a female does not nest properly or holds the eggs too long because she is not comfortable with the nesting situation, the majority of the eggs will not hatch. Proper nesting is defined as the female digging a burrow a few days to a few hours before laying, laying the eggs in a relatively timely matter (a few hours, not days), covering the nest, and (often) defending it (Lemm et al. 2005). Other factors potentially contributing to nesting failures include nutrition and incubation practices. At the Durrell Wildlife Conservation Trust, egg mortality was high in *I. delicatissima* until animals were supplemented with vitamin D_3 (R. Gibson, pers. comm.).

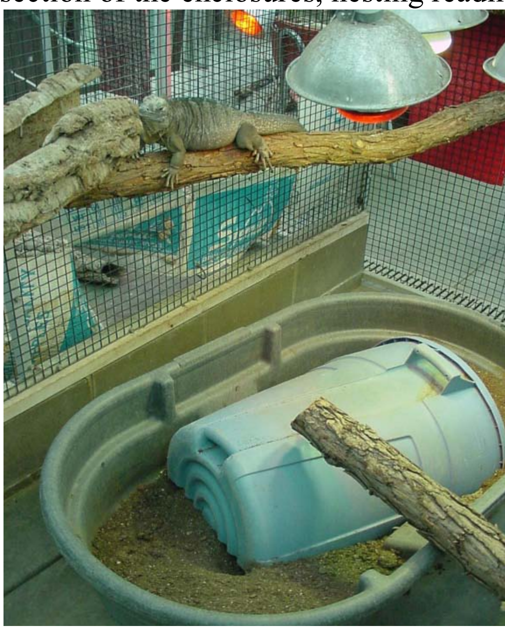
For aggressive species that cannot be housed together outside of the breeding season, small windows between cages will allow for visual and olfactory contact.

Off-display *C. collei* enclosure showing adjoining cages. This system was used successfully at CRES (San Diego Zoo) for pairs of *C. collei* in which the male becomes overly-aggressive towards the female after the breeding or nesting season.

A pair of Allen Cays iguanas (*C.c. inornata*) copulating in the wild. Photo by John Iverson

To achieve nesting success, nesting areas should be deep, spacious, and warm (85-87 °F/29.4-30.6 °C) with optimal soils. Ideally, the substrate throughout the cage should be at least three feet deep so females may choose to nest in a variety of places. At many facilities, especially off-display areas, this depth of substrate is not possible. In this case, built-in nestboxes, constructed to be as large as possible should be used. At ICR, nestboxes measuring 4 ft x 4 ft x 3ft high (1.2 m x 1.2 m x 0.9 m) have been used with some success. Further, plastic nestboxes, made from large Rubbermaid® or other boxes, have worked for some species. However, these nestboxes are usually only successfully used by young animals or first-time breeders for the first year or two, followed by below-average nesting (J. Lemm, pers. obs.). Indianapolis Zoo has had nesting success with Rubbermaid® tubs that are completely buried in sand substrate. Animals enter these tubs by digging down and entering a hole cut in the side of the tub.

Some institutions have used sand, rich soils, or a mixture of the two with success. Nesting soil should be free of rocks, gravel, and other large debris. Sifted dirt is used at ICR, as it holds moisture that in turn keeps burrows from collapsing. Nests are misted three times a week or whenever they become dry. For pickier nesters, items such as rocks or logs may be necessary for animals to burrow underneath. At ICR, nestboxes are situated in the sunniest corners of each cage. They are usually used to some degree, but on occasion animals choose to lay in the warmer dogloos. To discourage this, plastic pig blankets (Stanfield ®) placed on rheostats have been used under the soil. Nests are changed annually depending on how well the animals laid the previous year. Nests may be completely dismantled and reconstructed differently after poor nesting, or left alone after successful nesting. Various types of trashbins, plastic tubs, or soil placed in plastic dogloos have been used, but not as efficiently as the larger nesting areas. Although there has been some success with artificial nesting areas, it is usually in small females. Larger female iguanas rarely lay good eggs or nest well in artifical nesting areas. Indianapolis Zoo reports that their animals usually nest near a heat source and that most tunnels are proximal to heated rocks. At ICR, red lamps have been placed above nesting areas when outdoor temperatures were below average. Every female that was gravid at the time of the low temperatures constructed nests and laid eggs in chambers below the red lamps. In our new facility at the Wild Animal Park, all gravid females have laid in the indoor section of the enclosures, nesting readily in the deep soil.



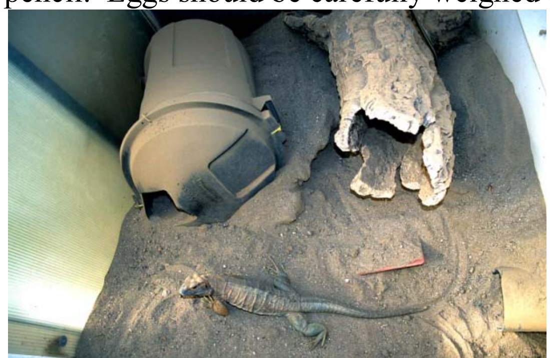
Off-display nesting area for *C. collei* at Sedgewick County Zoo.
Photo by Veronica Laflin

Nesting boxes work well for young or first-time breeders. The nest of this *C. n. nubila* has been exposed to show the eggs.

Nesting area used by *C. collei* at CRES, San Diego Zoo. The house was heated by 2 Pearlco ceramic bulbs.

Cyclura typically only lay one clutch of eggs per year, and some species may skip a year of reproduction under wild conditions (Iverson et al. 2004). However, Burton (2004) mentions double-clutching in female *C. lewisi* in the same year. Multiple-clutching is often fairly common in captivity. At ICR we have seen female *C. n. nubila* lay up to three clutches in a single season (April-October), usually spaced 2-2.5 months apart. On average, smaller females in our facility usually only produce one clutch per year (*C. collei, C. lewisi*), while some larger females sometimes produce two clutches in a single year (*C. n. nubila*).

After oviposition, females that have laid fertile eggs often guard the nest. Occasionally those that have laid infertile clutches will guard nests as well, but to a lesser degree. In most species it is easy to tell when a female has laid, as the burrow has been closed and the female looks thin. However, some species, such as *C. collei*, tend to maintain their shape after laying and nests need to be carefully inspected. If the female aggressively defends the nest, she should be captured briefly until the eggs are collected and the nest can be excavated and refilled. Finding eggs can be very difficult and care must be taken when digging, especially in corners where iguanas often deposit eggs. Eggs should never be rotated from the position in which they were found, and in order to keep track of individual eggs, numbers can be written directly on the eggshell with a pencil. Eggs should be carefully weighed and measured and placed in incubators.



Captive iguanas will usually guard the nest area after eggs are laid. Both animals in these photos chose to lay in the trash bins, which were located within large nesting areas in the corners of their indoor cages. The *C. collei* (top left) laid infertile eggs while the *C. pinguis* (top right) shown here produced the first clutch of offspring in a zoological facility from this nest. The eggs have been exposed for the photo (bottom).

Perlite or vermiculite should be used as incubation medium. The mass of substrate should equal 3-5 times the mass of the total clutch of eggs, and should be placed in a large plastic box with a loose-fitting lid. It is important that ample airspace is provided above the eggs within the box. An optimal incubation box should have as much air space as substrate. Substrate is mixed with water at a ratio of one to one, by weight, and incubated at 84.2 - 87.8 °F (29.0 - 31°C). The 1:1 substrate to water ratio is used in most facilities and is valuable in situations where eggs are slightly desiccated (usually because eggs were not found in a timely manner or nesting substrate was too dry). Using the 1:1 ratio, egg boxes rarely need to have water added to them, depending on the type of incubator and ventilation of boxes. Some facilities use a Perlite/vermiculite to water ratio of 2:1. This ratio is most often used in facilities that weigh egg boxes regularly and add lost water upon each weighing. The 2:1 ratio is also useful in instances when the incubator in use does not have a fan or egg boxes do not ventilate well, and so the drier mixture helps keep excess moisture from building up on the inside of egg box lids and dripping on the eggs.

Eggs should be placed on top of the substrate and not in contact with other eggs and not buried in the substrate mixture. Some facilities choose to weigh egg boxes weekly and add water that is lost over time. This works well up until the last few weeks of incubation, but increasing water at this time may kill the embryos. Generally, water replacement is done during the first two-thirds of the incubation period only. Some institutions add small amounts of water to the substrate if the eggs start to look too dry. When using this method, warm water can be sprayed between eggs (never directly on eggs) with a spray bottle, or eggs can be removed and substrate can be sprayed evenly. If substrate such as vermiculite stays clumped when squeezed by hand, the moisture level is optimal. Egg boxes should have loose lids that allow for minimal air exchange and lids should be removed briefly about every 1.5 - 3 weeks during the first two months of incubation for additional air exchange. Near the end of incubation (70-128 days, depending on species and incubation temperature), lids are removed daily to allow for the increased respiration rates of the developing embryos. Water is never added during the last trimester of incubation, when eggs begin to lose weight and begin to wrinkle prior to hatching. Some eggs may start to develop mold spots even when they are fertile. Gently wiping egg surfaces with a cotton swab and 1% iodine solution to remove mold spots has worked well at some institutions on a number of occasions.

Egg incubation box for *C. pinguis* at CRES, San Diego Zoo.

If breeding, nesting, and incubation were successful, hatching success is usually quite high. When full-term, healthy-appearing young pip and die or fail to pip, a probable cause of death is adding too much water to the egg boxes during the final weeks of incubation (J. Lemm, pers. obs.). Hatchlings commonly stay in the egg for up to a day with just their heads sticking out. Wild nest temperatures for *C. collei* have been measured and fluctuate from 83.3 – 92.3° F (28.5 – 33.5 °C). Wild *C. pinguis* nests range from 83.1 – 91.2 °F (28.4 – 32.9 °C). While successful incubation has been recorded at both extremes of these ranges, the recommended protocol above represents the mean in which hatchlings can be expected to emerge with their yolk sacs absorbed.

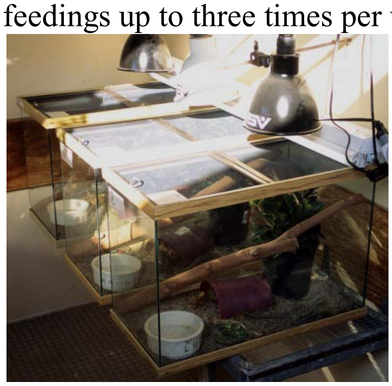
Left: It is common for hatchling iguanas to stay inside the egg with just their head sticking out, at least for a couple of hours. This is a *C. pinguis*.
Right: A wild hatchling *C. pinguis* emerges from a nest.

Viable *C. collei* embryo inside the egg. Photo by Richard Searcy.

The first captive-bred *C. collei* outside of Jamaica. Photo by Richard Reams.

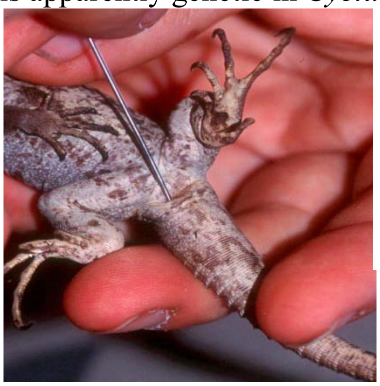
Hatchling Care

Hatchling iguanas should be removed from incubation boxes immediately and placed in small tubs on clean, moistened paper towels. New hatchlings should be housed individually as they can easily injure one another. Boxes can be placed back in the incubator until the umbilical scars close and heal and yolk sacs are completely absorbed. Swollen or bleeding yolk sacs/umbilical regions should receive immediate veterinary care. In some cases they may need to be removed manually if they do not heal properly. Once umbilici are healed, hatchlings can be housed separately in 10-20 gallon terraria or housed in a group in larger enclosures. When housed separately in terraria, most soil substrates work well in conjunction with small plants and a small water dish. A temperature gradient of 75 - 85 °F (23.9 - 29.4 °C) should be maintained with a hide area on both sides of the gradient. Hatchlings should be misted 3-5 times a week, as they may not recognize water dishes at this age. It is also advisable to keep a small portion of the substrate moist at all times as young iguanas dehydrate quickly when basking at high temperatures, especially if they have not yet started eating large amounts. A suitable basking site up to 120 °F (48.9 °C) on the basking surface is sufficient. Ultraviolet light is necessary and very important for proper bone mineralization in young iguanas. Hatchlings should be fed every day. Some institutions rotate insect feedings with salad feedings up to three times per week.



Cages for newly hatched iguanas at CRES, San Diego Zoo.

Within the first month of hatching, the gender of individual animals can be determined by using sexing probes. These small, metal probes are lubricated and gently inserted into the cloaca, pointing toward the posterior of the tail. This is a delicate procedure that should be performed by experienced keepers and veterinarians because injury to the male reproductive organs (hemipenes) is possible. The probe depth is greater in males at the point where the probe enters the inverted sacs containing the hemipenes. Probe depths vary among species, although species of similar body size usually have comparable probe depths. In the smallest species of rock iguana (*C. c. carinata*), probe depths of hatchling males and females are 10+ mm and 4+ mm, respectively. In adults, probe depths are 25+ mm for males and under 15 mm for females. In larger *Cyclura*, such as *C. n. nubila*, hatchling male and female probe depths measure 15-20 mm and around 4-8 mm, repectively. Adult *C. n. nubila* probe depths range from 25-40 mm for males and 12-15 mm for females. Because sex determination is apparently genetic in *Cyclura*, sex ratios in clutches should be near unity.



Gender is easily determined by probing hatchling iguanas. This procedure should be done by trained professionals as hatchlings can be injured during this process.

Passive integrated transponder tags (PIT tags) for animal identification can be inserted into the left rear thigh of hatchlings of most species as early as one month after hatching. In the past, PIT tags were inserted into many locations, including the legs, body wall, and neck; however, the Iguana Specialist Group (ISG) is following conventions established by the IUCN/SSC Conservation Breeding Specialist Group and has agreed upon the left rear thigh as an insertion site. Because of the risk of injury to the animal, PIT tag insertion should only be undertaken by trained personnel.

All captive animals should receive a passive integrated transponder (PIT) tag for identification purposes. This procedure should be carried out by trained professionals and involves injecting the tag under the skin, normally in the left rear thigh.

When housed in groups, hatchling iguanas establish a dominance hierarchy relatively quickly. Numerous and spatially dispersed food bowls, basking sites, and retreats should be provided as soon as larger animals begin to show evidence of dominating smaller ones. Separate enclosures may be needed for smaller hatchlings that appear thin or stressed or who constantly hide. Within the first year of hatching, future mates (identified by the studbook keeper) can be housed together. At ICR, large, plastic vegetable bins (RK2 Systems) measuring 4 ft x 4 ft x 3 ft (1.2 m x 1.2 m x 0.9 m) high are used for up to three yearlings (for more aggressive species such as *C. lewisi*, hatchlings may need to be housed individually). Bins are covered with a wood frame on which 0.5 x 1.0 in mesh has been attached. Hatchlings and juveniles are housed indoors and basking heat is provided by a 250-watt Pearlco ceramic heater and 275-watt Active UV Heat bulbs. PVC tubes with heat tape lining the inside are used as nighttime retreats. Dirt is used as a substrate at a sufficient depth to allow the animals to burrow. At 2-3 years of age, juveniles are transferred to adult enclosures. St. Catherine's Wildlife Survival Center has had similar success raising hatchlings and juveniles in covered cattle troughs.

Vegetable bins with mesh lids have proven to work well for housing juvenile iguanas at CRES, San Diego Zoo.

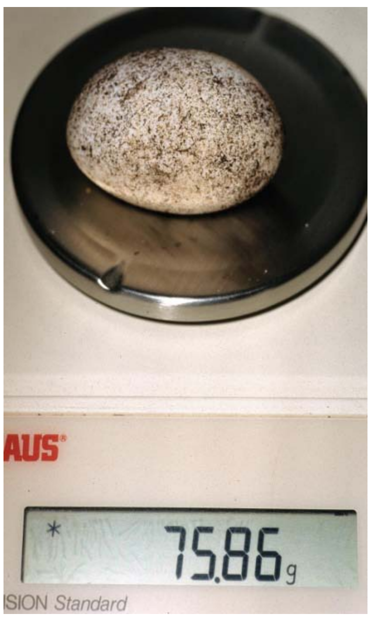
These four *C. pinguis* were the first hatched at CRES, San Diego Zoo.

Record Keeping

A comprehensive database should be kept for all species of West Indian iguanas in captivity. Records of feeding, diet change, temperature, humidity, captures, animal moves, copulation, egg-laying, veterinary treatments, or any other important notes should be kept on a daily checklist that can be later entered into a computer database. Because some species have only been held in captivity for a short time, growth data are very important for husbandry and research purposes. Hatchlings, juveniles, and adults are weighed and measured by most facilities at least once a month. Optimal sets of measurements include: head length and width (mm), jowl or head width (mm), SVL (mm), tail length (mm), and mass (g or kg). For older animals that are easily stressed by capture, some facilities choose to measure their adult animals every few months and may not disturb them during the breeding season. Female body mass before and after egg-laying are important records to keep in order to monitor health, as some female iguanas may lose up to a third of their body mass following oviposition. Other notes on captive reproduction are useful as well, including: studbook numbers of parents, notes on nesting, egg mass (g), egg length and width (mm), incubation media, water potential and temperature during incubation, time of incubation (oviposition to hatching), and hatchling measurements. Some facilities and researchers also note the probe-depth (in mm) when sexing hatchling iguanas. Studbook numbers of parents, hatchling gender, the institution's identification number for each hatchling, and the PIT tag number should all be sent to the West Indian iguana studbook keeper as soon as possible after hatching.

Iguanas, such as this large *C. n. nubila*, should be weighed at least once a month to help gauge overall health and food intake.

Jeff Lemm measures snout-vent length (SVL) in a wild *C. c. carinata*. SVL and tail measurements should be recorded at least once a month in captive iguanas.



Egg mass, length, and width should always be recorded for both fertile and infertile eggs. This is an average size *C. n. nubila* egg.

Husbandry Protocol for the Lesser Antillean iguana (*Iguana delicatissima*)

By Jeffrey M. Lemm

Captive *I. delicatissima* are currently held by three institutions: the Detroit Zoo, Durrell Wildlife Conservation Trust, and the Memphis Zoo (previously a pair of the Memphis animals was housed by ICR, San Diego Zoo). All animals originate from a highly arboreal population of iguanas from Dominica and the following information is tailored to these animals. Populations from more xeric islands may spend significant time on the ground and as a result, their husbandry parameters in captivity may vary. The captive husbandry of *I. delicatissima* is intermediate between that of *Cyclura* and the green iguana (*I. iguana*). Tall, spacious enclosures are important, as *I. delicatissima* prefer to bask and roost at the highest points of the enclosure. They are also somewhat flighty and a high, heavily planted enclosure will help give them a sense of security.

Enclosure size should be at least 3m w x 3m l x 3m h for a pair of animals. It may also be necessary to separate animals at various times of the year. To facilitate this, enclosures should be equipped to allow seasonal division.

Tall, spacious enclosures were used to house *I. delicatissima* at CRES, San Diego Zoo. Height is essential in making these iguanas feel secure. The roof was also constructed of Solacryl plexiglass for some UVB transmission.

Quarantine procedures discussed for *Cyclura* can be applied to *I. delicatissima*. Health problems in newly acquired animals documented to date include red mites, strongyles, oxyurids, and *Salmonella*. Strongyles and oxyurids were eliminated after three doses of fenbendazole (administered orally, 100 mg/kg body weight) spaced two weeks apart. Animals carrying *Salmonella* were treated with ceftriaxone sodium (50 mg SQ SID for seven days) (Reichling, 1995). Other health problems reported in captive animals include egg-binding, torn nails, broken tails, and in one instance, a luxated femur. The hip luxation was corrected by surgically removing the head of the femur allowing the muscle tissue to act as a hip joint. This animal has recovered well and, although she moves slowly and does not have full mobility, she can still climb and dig (J. Lemm, pers. obs.)

Full-spectrum illumination is as essential for the captive maintenance of *I. delicatissima* as it is for *Cyclura*. The same methods of UV-illumination described for *Cyclura* can be applied to *I. delicatissima*. Enclosure humidity guidelines for captive rock iguanas can also be applied. The Durrell Wildlife Conservation Trust maintains that optimal humidity levels are around 60-70% and should exceed 70% during the rainy season, from July to December (when cages are sprayed frequently). *I. delicatissima* seem to bask at lower temperatures than *Cyclura* and often pant and move to the enclosure floor in extremely warm weather. A temperature gradient of 75 - 85 °F (23.9 - 29.4 °C) should be maintained for most of the year. A slight winter cooling will not harm the animals and may aid in reproduction. A basking spot up to 120 °F (48.9 °C) (surface temperature) is suitable throughout the year.

Wild-caught specimens are very particular in the foods they will accept. There is a seasonal shift in diet from folivory during the dry season (Dec.-May) to frugivory and folivory during the wet season (Day 1991). Animal protein in the form of bird eggs and carrion is also taken on occasion. Reichling (1996) recommends fresh figs, grapes, sweet potato leaves, cranberries, mango, and papaya for newly acquired animals. With time, they will accept a variety of foods, and diets described earlier for *Cyclura* can be fed to *I. delicatissima*. Useful plants for browse include *Ficus*, *Hibiscus*, and *Pseudoacacia*, and the leaves of mulberry and lime trees are often eaten as well. Water should always be available to the animals, although *I. delicatissima* rarely, if ever, drinks from a water dish. Instead they lap water sprayed onto branches and leaves of the enclosure.

Adult *I. delicatissima* prefer greens and leaves that are large in size.

Wild *I. delicatissima* have an extended breeding season and gravid females can be found from February to August. More than one clutch per year may be possible, but most captives only lay a single clutch per year. Breeding and oviposition have been observed at Durrell Wildlife Conservation Trust, San Diego, and Memphis Zoo since 1994; however, success has been limited at the latter two institutions. At ICR, animals are sometimes separated for part of the year and mirrors have been used to stimulate the male. Temperature and light cycle manipulation seem to be the main reproductive triggers in captives.

Mirrors were used successfully at CRES, San Diego Zoo, to elicit breeding behaviors in *I delicatissima*. Males would fight with their reflection and become more aroused in the presence of females.

Durrell has been the only institution to date to produce offspring (one hatchling in 1997, and 8 in 2000). ICR has had individuals from two clutches die in the egg at full term, and all facilities have had problems with infertility. These problems may be similar to *Cyclura*, in that if the eggs are not properly nested or held too long, the eggs simply die. Proper nesting has been difficult to achieve with captives. Properly nested eggs or those that were nested in the soil rather than scattered around enclosures were hatched successfully or died full-term, whereas those dropped or scattered around enclosures failed to develop and molded quickly. Breeding and nesting usually take place in captivity between January and July. The clutch of eight that hatched at Durrell were oviposited and defended properly in an upright trashcan approximately 1m (3.3 ft) high and 0.5 m (1.65 ft) in diameter. A slightly damp substrate of half soil and half sand was heated by an Ultratherm® heat mat taped to the outside of the bin, roughly one-third of the way up from the bottom. Half the lid of the trashcan was removed and a tree branch was placed inside the bin so the female could climb in and out. At ICR, the female ignored the nesting area on the ground and chose to nest her first clutch in a potted *Ficus* plant; one of these eggs developed to full-term and died, while all other eggs were believed to be infertile. The only other fertile eggs at ICR were oviposited in a large plastic tub that was filled with soil and elevated about 5 ft off the ground (again, the female ignored the spacious nesting area on the floor). Two eggs developed to full-term and died and all the other eggs appeared infertile. Fertile eggs at Durrell were incubated in a mixture of water and vermiculite (1:1, by weight) at 82.4 - 86 °F (28 - 30 °C) for 93-96 days. Hatchlings can be housed and raised much like *Cyclura* or *I. iguana* and Gibson (pers. comm.) believes hatchlings feed and fare better in social groupings.

Female *I. delicatissima* nesting in a potted *Ficus* tree.

I. delicatissima nest in *Ficus* tree pot.

Full-term *I. delicatissima* that failed to hatch from the egg at CRES, San Diego Zoo.

Durrell considers their husbandry, dietary shift (similar to wild diet shift to and from frugivory), and the use of oral D_3 supplementation to be the major reasons for their success in 2000. Woodstock's Nutritional Supplements "Oily D_3" is presented to the female iguana on a choice food item at weekly intervals (300 iu/week). The following day's feed includes a finely-chopped pile of cuttlefish bone. Doses are increased to 600 iu/week during the three months prior to the breeding season. Proper nesting, access to UVB irradiation, and high basking temperatures all appear to play a major role in successful reproduction of *I. delicatissima* in captivity.

Wild hatchling *I. delicatissima* from St. Eustatius.
Photo by G. Gerber

Nutrition

By Ann M. Ward

Captive diets

Food categories and suggested ranges, with flexibility for seasonal changes and foods available.

Table 1 outlines food item categories and suggested ranges for these food categories in the diet. Table 2 provides general specifications for nutritionally complete pelleted diets. Following the outline categories and ranges, utilizing feeds meeting the specifications in table 2, will allow the diet offered to meet the target nutrient levels outlined in Table 3. The ranges will allow flexibility for species differences as well as differences in foods available to institutions. No supplements are recommended considering food items fed and consumed in the below proportions meet the current target nutrient levels. Supplementing one or more nutrients can result in toxic levels and/ or imbalances if not calculated as an ingredient in the diet. See Allen and Oftedal (2003) for supplement considerations.

Table 1: Food categories and suggested ranges with flexibility for seasonal changes and foods available[1]

Ingredient	% of Diet As Fed
Nutritionally complete feeds[2]	35-100
Leafy greens[3]	50-55
Vegetables[4]	2.5-5
Fruits[5]	0-5
Animal matter[6]	0-2.5
Browse[7]	0-10

[1]See appendix for nutrient analysis of diets. Appendix table A.
[2]The nutritionally complete feed should meet or exceed the specifications in table 5. Note the above categories are appropriate for growing and maintenance animals if a higher protein, higher phosphorus complete feed is used for growing animals. Nutrient analysis of dry biscuits/pellets fed to iguanas is in Appendix Table B.
[3]romaine,celery, collards, kale, mustard greens.
[4]carrots, broccoli, sweet potato, peas.
[5]apple, banana, grape, papaya.
[6]crickets, mealworms, omnivorous gel diet.
[7]bamboo leaves, mulberry leaves, hibiscus leaves.

Several publications have addressed concerns regarding oxalates, phytates, and glucosinilates in produce items (Allen and Oftedal 2003, Donoghue 2006). In general, problems can be avoided if a varied diet is offered, avoiding one or a few food items contributing significantly. Inclusion of produce often encourages animals to consume the nutritionally complete feed. Grinding or softening the complete feed and coating the produce can facilitate consumption. Consumption of the diet should be recorded and assessed based on the animal's body condition, physiological state, and food items or total food remaining. *Cyclura* spp. are predominately herbivorous. They should be offered food daily. Commercially available produce items do not accurately reflect fiber levels found in natural food items. See Appendix Table C for fiber levels in commonly available produce items compared to foods consumed by free-ranging animals.

Table 2: General specifications for a nutritionally complete feed on a dry matter basis that, fed in the above proportions, will meet target nutrient levels.

Nutrient	Units	Level in Feed
Protein	%	Min 14.0 adult, 17.0 growing
Fat	%	3.0
Linoleic acid	%	2.0
Crude fiber	%	10.0
Acid detergent fiber	%	13.0
Calcium	%	1.0
Phosphorus	%	Min 0.8 adult, 0.9 growing
Potassium	%	0.5
Sodium	%	0.2
Magnesium	%	0.2
Iron	ppm	100.0
Copper	ppm	15.0
Manganese	ppm	60.0
Zinc	ppm	100.0
Iodine	ppm	1.0
Selenium	ppm	0.35
Vitamin A	IU/kg	7000
Vitamin D_3	IU/kg	2100
Vitamin E	IU/kg	200
Vitamin K	ppm	1.0
Vitamin C	ppm	200.0
Thiamin	ppm	10.0
Riboflavin	ppm	5.0
Pantothenic acid	ppm	20.0
Niacin	ppm	125.0
Vitamin B6	ppm	10.0
Folic Acid	ppm	1.0
Biotin	ppm	0.5
Vitamin B12	ppm	0.03
Choline	ppm	1500

Target nutrient ranges

Due to the lack of species specific data, it is reasonable to consider the known requirements of related domestic animals. Domestic models have been studied in great detail, and thus provide a database from which to extrapolate. A range of probable requirements can be established for *Cyclura* based on animals with similar feeding ecology, and gastrointestinal tracts. Data on herbivores including green iguanas (Allen and Oftedal 2003), horses (NRC 1989), and rabbits (NRC 1977) have been used. Where data points were missing, information on the omnivorous dog (AAFCO 2004) were used as a guide. *Cyclura* species are primarily herbivorous, with some reports of opportunistic consumption of animal material.

In general, these levels represent minimums for most nutrients. Based on the products available, and sample diets presented below, most diets provide levels exceeding these targets. It is not unusual for many diets currently offered to adults to already meet or exceed the minimums for growing animals as well. Recommendations for egg laying were not made due to a lack of species specific data. For poultry in maximum egg production, calcium levels fed may reach 3% of the diet (NRC 1994). Levels up to 2% should be safe for iguanas. Levels above 2.5% are not recommended considering potential interference with the absorption of other minerals (Klasing 1998). During all physiological states adequate vitamin D is required for normal calcium metabolism.

Table 3: Suggested target nutrient ranges for growing and maintenance iguanas on a dry matter basis.

Nutrient	Units	Target nutrient range Dry matter basis
Protein	%	17-26 Growing; 12-17 Maintenance
Fat	%	3
Linoleic acid	%	1
Crude fiber	%	6-10
Acid detergent fiber	%	13-18
Calcium	%	1.0 Growing; 0.6 Maintenance
Phosphorus	%	0.8 Growing; 0.5 Maintenance
Potassium	%	0.5
Sodium	%	0.2
Magnesium	%	0.15
Iron	ppm	80
Copper	ppm	10
Manganese	ppm	50
Zinc	ppm	82
Iodine	ppm	0.6
Selenium	ppm	0.3
Vitamin A	IU/kg	5000
Vitamin D_3	IU/kg	-
Vitamin E	IU/kg	150
Vitamin K	ppm	1
Vitamin C	ppm	200
Thiamin	ppm	8.0
Riboflavin	ppm	5.0
Pantothenic acid	ppm	15.0
Niacin	ppm	90
Vitamin B6	ppm	6.0
Folic Acid	ppm	0.8
Biotin	ppm	0.25
Vitmamin B12	ppm	0.03
Choline	ppm	1200

A comprehensive review of the role and importance of the macro and micro-nutrients is provided by Allen and Oftedal (2003) in Jacobson (2003).

In general, quantifiable differences in nutrient requirements for growing iguanas and adult maintenance iguanas have not been determined. Investigations with hatchlings and juveniles have identified differences in growth rates based on protein and fiber levels fed (Allen, et al. 1989, Baer et al. 1997, Donoghue 1995). Calcium and phosphorous levels are those suggested to maintain adequate growth in herbivorous and omnivorous mammals. Currently, no dietary level of vitamin D_3 has been shown to avoid vitamin D deficiency. Consequently, all iguanas should be provided with an adequate source of UV light in the range supporting the most effective biogenesis of vitamin D at the 295-300 nm range (Holick 1995).

Seasonal changes:

Few data exist quantifying differences in nutrient intake with season (wet/dry; nonbreeding/breeding) in free-ranging iguanas. Investigations to date are limited to *I. iguana*. These studies indicate significant variation in metabolizable energy intakes of free ranging *I. iguana* within seasons, making between season comparisons difficult (van Marken Lichtenbelt et al. 1997). Different types of foods (fruits, flowers, young and old leaves) are consumed by iguanas on Jamaica, and Grand Cayman depending on the season (Vogel 1999, Burton 2005). Due to the seasonal climate, it is suspected that seasonal variation occurs on other islands that *Cyclura* inhabits.

Preliminary data, including those from a limited number of captive *C. lewisi* in the Grand Cayman Breeding and Headstart Facility and two US institutions (Indianapolis Zoo and Gladys Porter Zoo), indicate little, if any difference between breeding and nonbreeding seasons, in dry matter, crude protein, and acid detergent intakes on a gram per day per kilogram body weight basis, though diets offered varied in nutrient content. Animals with a good history of reproductive success at the headstart facility may have consumed more of a lower protein diet during the breeding season such that overall protein intake did appear different between breeding and nonbreeding seasons. On a dry matter basis, the protein content of the diet consumed at the headstart facility during the breeding and nonbreeding seasons was 18% and 9%, respectively. Crude protein intake (g/d/kg body weight) for adults at the headstart facility, Indianapolis Zoo, and Gladys Porter Zoo were 0.51 ± 0.02, 0.70, and 1.34 ± 0.40 (A.M. Ward and J.L. Dempsey, 2006, unpublished data).

The above suggested ranges of ingredients allow the incorporation of flowers, fruits, and nontoxic natural plants (browse) to vary by season if desired. It is not appropriate to offer an unbalanced diet at any time.

Sample diets:

Table 4 outlines two successful sample diets from zoological institutions in the US that have had reproductive success. Table 5 provides the nutrient analysis of those two diets. Appendix Table D reviews the nutrient analyses of some diets consumed in zoological institutions and headstart facilities. A detailed summary of these analysis for captive and headstarted *C. collei*, headstarted *C. pinguis*, and headstarted *C. lewisi* is provided in Ward et al. 2001, 2003, and 2005. A comprehensive review of protocols currently in place at ICR is provided in appendix E.

Table 4: Diets offered to *Cyclura* spp. at San Diego Zoo and Indianapolis Zoo by food category on an as fed basis.

Food Category	As fed % of the diet	
	San Diego Zoo[1]	Indianapolis Zoo[2]
Nutritionally complete feed	5.6	0
Leafy vegetables	80.0	79.0
Vegetables	4.8	11.8
Fruit	2.4	9.0
Animal matter	7.2	0
Browse	0	0
Supplements	0	0.2
Total	100	100

[1]Diet amounts provided in 2003 are offered, not consumed. Browse is offered but the amount was not quantified.
[2]Diet amounts were collected in 2005 by the authors as offered, not consumed.

Table 5: Nutrient analysis of the diet offered at San Diego Zoo and the diet consumed at the Indianapolis Zoo on a dry matter basis.

Nutrient	Units	On a dry matter basis	
		San Diego Zoo[1]	Indianapolis Zoo[2]
Protein	%	22.9	26.7
Fat	%	3.9	6.1
Acid detergent fiber	%	11.6	13.0
Calcium	%	1.2	4.1
Phosphorus	%	0.6	0.52
Potassium	%	2.4	3.8
Sodium	%	0.5	0.4
Magnesium	%	0.3	0.4
Iron	Ppm	201.6	171.8
Copper	Ppm	11.4	5.8
Manganese	Ppm	54.6	94.6
Zinc	Ppm	67.9	30.8
Vitamin A	IU/kg	176840	-
Vitamin D_3	IU/kg	709	-
Vitamin E	IU/kg	167.8	-
Vitamin K	Ppm	-	-
Vitamin C	Ppm	2526	-
Thiamin	Ppm	8.8	-
Riboflavin	Ppm	12.2	-
Pantothenic acid	Ppm	16.2	-
Niacin	Ppm	61.7	-
Vitamin B6	Ppm	4.4	-
Folic Acid	Ppm	3.1	-
Biotin	Ppm	-	-
Vitamin B12	Ppm	-	-
Choline	Ppm	-	-

[1]The nutrient analysis is of the offered diet utilizing a diet card provided by the San Diego Zoo with a calculated analysis done using the Animal Nutritionist program.
[2]The nutrient analysis is of the diet consumed by 1.1 *C. lewisi* done by chemical analysis. Missing values indicate the analysis was not completed. Due to the mixed ingredient nature of this diet it was not possible to separate food items remaining to do a calculated analysis.

Nutrition related health concerns

Metabolic bone disease (MBD).

Several calcium metabolism disorders are grouped under metabolic bone disease. These are well reviewed by Allen and Oftedal (2003) and include: nutritional secondary hyperparathyroidism, fibrous osteodystrophy, rickets, osteomalcia and metastatic mineralization. Metabolic bone disease is a complex group of conditions due to the involvement of diverse nutrients, metabolites, hormones, and organs supporting both nutritional and nonnutritional causes. Nutritional causes include insufficient levels of calcium, and/or vitamin D (lack of expose to UV light in the appropriate wavelength range), and imbalanced calcium to phosphorous ratio in the diet. It is interesting to note metastatic mineralization in humans occurs as a result of hypervitaminosis D while some cases of metastatic mineralization in green iguanas appears to be the result of hypovitaminosis D (Richman, et al. 1995). Considering these problems can be multifactorial, it is important in assessing to review the calcium, phosphorus, calcium to phosphorous ratios, and vitamin D levels in the diet as well as in the serum. Additionally, non-nutritional factors such as renal disease can affect some of these serum parameters. Thus, it is important to review the overall health of the animal.

Gout.

High protein diets have often been suggested as a cause of gout. However, controlled studies to date in iguanas are few and do not support this theory. As reviewed by Allen and Oftedal (2003), diets fed iguanas containing protein levels as high as 35% did elicit a rise in serum uric acid levels, but these were within the reported normal range for hydrated reptiles of 1-8 mg/100 ml. A combination of ingredients fed within the suggested ranges above would not exceed an overall protein level of 35%. Considering elevated serum uric acid levels can reflect a natural post-prandial rise or dehydration or renal insufficiency, values should be interpreted carefully.

A juvenile *C. lewisi* with gout – note the swollen forelimb.

Vitamin D needs and assessing vitamin D status

Meeting vitamin D needs.

Considering the still common occurrence of MBD and studies indicating normal dietary levels of vitamin D_3 do not prevent rickets in captive *I. iguana* (Bernard et al. 1991), exposure to ultraviolet radiation within the appropriate range appears to be the most effective method of meeting vitamin D requirements. The range for UVB is 280-315 nm. Peak conversion of provitamin D_3 to previtamin D_3 in the skin of humans occurs in a narrow band between 295 and 300 nm (Holick 1995). The final conversion of previtamin D_3 to vitamin D_3 in the skin is temperature dependent.

UVB.

Outdoor exhibits/exposure to natural sunlight, UVB-emitting bulbs, and UVB-penetrating skylights are appropriate methods of supplying UVB. Methods that supply light in the 295 to 300 nm range are the most effective. Distance of the lamp from the animal as well as the decrease in UV output over time must be considered in the placement/replacement of the bulbs (Bernard 1995). Most bulbs provide a combination of light, including visible light, UVA radiation, UVB radiation, UVC radiation, infrared radiation, or combinations. Too much or inappropriate radiation can result in tissue damage (Gallagher 2006). Consequently, all bulbs should be used with caution. Ultraviolet meters, radiometers and ampoules have been used to determine the effectiveness of bulbs and skylights. Instruments that read within the peak conversion range will provide the most valuable assessment of vitamin D synthesizing capacity. Ampoules containing a solution of 7-dehydrocholesterol in n-hexane when exposed to light can be used to measure vitamin D conversion (Holick et al. 1995). A comprehensive review of this topic and the relationship to reptiles is available in Bernard (1995). A review of broadband radiometers and light bulbs can be found in Gehrmann et al. (2005) with additional assessment of bulbs in Schmidt et al. (2006).

Oral vitamin D supplementation.

Supplements used for a variety of animals are provided in Ullrey and Bernard (1999). Levels known to be toxic to other species do not appear to have the same affect on iguanas. A large single oral dose (8.5 IU vitamin D_3/g of body weight) did increase serum 25-hydroxy D_3 levels but could not sustain normal serum levels up to 5 weeks (Bernard 1995). The long- term effect of repeated large oral doses has not been studied.

Assessing vitamin D status.

Regardless of assessment of light, regular serum analysis for 25-hydroxy D_3 should be conducted to ensure the lights/skylights are maintaining the animals within a normal range year around. See animal health section for serum normal values. Serum 25-hydroxy D_3 is the most valuable metabolite to assess vitamin D status because it reflects diet and biogenesis over several weeks to months (Holick 1990).

Serum nutrients

Serum nutrient levels have been used to assess nutrient status though many are not ideal and have limitations. Serum levels of retinol only reflect vitamin A status if very low or very high in humans (Crissey et al. 1999). Serum retinol has been used to note dietary levels consumed (Crissey et al. 2003). Serum alpha tocopherol can be correlated with liver stores (Crissey et al. 2003). However, different animals of the same species tend to exhibit individually characteristic alpha tocopherol levels (Shrestha et al. 1998). Published values do not exist for these vitamins or the carotenoids for *Cyclura* spp. Due to the small sample sizes and large degree of variation, interpretation of the unpublished values in Table 8 are difficult. Values for free ranging *C. r. rileyi* appeared to overlap with captive headstarted *C. collei*, *C. lewisi*, and *C. pinguis* in most cases. In addition, these samples represent one point in time; no repeated sampling occurred for any animal. Values may reflect the diet consumed and not accrual stores. Except for the diet offered *C. lewisi*, and consumed by free ranging *C. r. rileyi*, all animals were fed a prepared diet containing little if any natural diet ingredients. Retinol and alpha tocopherol may not be different from those levels measured in *I. iguana* (Raila et al. 2002). Low levels of carotenoids may be a reflection of poor health status/illness in some zoo animals (Slifka 1999) thus establishing normal values on healthy animals should be pursued. All animals represented in the table below were considered healthy. Similar to *I. iguana*, these animals appear to absorb and/or accumulate the carotenoids lutein, zeaxanthin, and to some extent canthaxanin (Raila et al. 2002). Beta carotene does not appear in the serum, suggesting they cannot absorb intact beta carotene. However, they may be able to convert it to vitamin A at the brush border of the intestine similar to birds.

Table 6: Vitamin A (retinol), vitamin E (alpha tocopherol), and some carotenoids (beta carotene, lutein + zeaxanthin, and canthaxanthin) in the plasma of headstarted and wild *Cyclura* spp. in ug/ml.[1]

Species	N	Retinol	Alpha tocopherol	Beta carotene	Lutein + Zeaxanthin	Canthaxanthin
C. collei	7	0.014±0.038	2.770±1.223	nd	0.804±0.413	0.073±0.093
C. lewisi	3	0.136±0.047	0.482±0.590	nd	0.077±0.134	nd
C. pinguis	12	0.154±0.037	3.482±1.341	nd	1.635±0.691	nd
C. rileyi rileyi	17	0.117±0.014	4.897±3.000	nd	2.172±0.960	0.333±0.177

[1]Unpublished data Ward et al. 2003, A.M. Ward and J.L. Dempsey, 2002,2005, 2006.
. *C. collei*, *C. lewisi*, and *C. pinguis* captive headstart facilities; *C. r. rileyi* free ranging.

Natural diet

Comprehensive nutritional studies of wild *Cyclura* spp. do not exist that describe all the foods consumed across seasons, as well as their contribution to the overall diet, and their chemical nutrient analysis. Those data are needed to describe the free-ranging diet accurately. Investigators have described portions of the diets of *Cyclura* spp. by visually observing animals, by stomach contents, and by fecal remains (Table 7.). Baer (2003) notes stomach contents do not provide a complete assessment of diet because they are limited due to differences in the rate of digestion of different foods and the selective retention of different foods in the gastrointestinal tract. Though seeds in fecal remains may reflect fruits consumed, well digested leaves often are difficult to identify and some vegetation and soft bodied insects may be completely digested leaving no remains (Auffenberg 1982). The most comprehensive work to date continues to be Auffenberg's (1982) review of the diet of *C. c. carinata* which describes diet based on stomach contents and fecal analysis including chemical analysis of food items for energy content. These observations suggest *Cyclura* spp. are predominately herbivorous with some species consuming animal matter opportunistically and no indication the diet of hatchlings and juveniles differs from adults. A list of plants consumed by some *Cyclura* spp. is presented in Appendix Table F.

Table 7: Forage and food types consumed by free-ranging *Cyclura* spp.[1]

Cyclura Species	Plant Matter				Animal Matter
	Leaves	Fruits	Flowers	Other	
Turks & Caicos Iguana (*Cyclura carinata carinata*)[a]	X	X	X	X	X
Bartch's Iguana *(Cyclura carinata bartschi)*[b]	X	X	X		X
Jamaican Iguana *(Cyclura collei)*[c]	X	X	X		X
Rhinoceros Iguana *(Cyclura cornuta cornuta)*[d]	X	X	X		
Mona Island Iguana *(Cyclura cornuta stejnegeri)*[e]	X	X			X
Andros Island Iguana *(Cyclura cychlura cychlura)*[f]	X	X	X		
Exuma Island Iguana *(Cyclura cychlura figginsi)*[g]	X	X	X		
Allen Cays Iguana *(Cyclura cychlura inornata)*[h]	X	X	X		X
Cuban Iguana *(Cyclura nubila nubila)*[i]	X	X	X		X
Sister Isles Rock Iguana *(Cyclura nubila caymanensis)*[j]	X	X	X		X
Grand Cayman Blue Iguana *(Cyclura lewisi)*[k]	X	X	X	X	X
Anegada Island Iguana *(Cyclura pinguis)*[l]	X	X	X		X
Ricord's Iguana *(Cyclura ricordii)*[m]	X	X	X		X
San Salvador Iguana *(Cyclura rileyi rileyi)*[n]	X	X	X		X
White Cay Iguana *(Cyclura rileyi cristata)*[o]	na	na	na	na	na
Acklins Iguana *(Cyclura rileyi nuchalis)*[o]	na	na	na	na	na
Lesser Antillean Iguana *(Iguana delicatissima)*[p]	X	X	X		X

[1]These data gathered from published reports using methods of direct observation of feeding ecology, analysis of stomach contents, analysis of colon contents, and fecal samples.
[a]Auffenberg 1982. Other plant matter includes buds and mushrooms. Animal matter includes opportunistic ingestion of insects, crustaceans, rodents, fish, and birds.

[b]Buckner and Blair 2000a. Animal matter includes opportunistic ingestion of insects, mollusks, crustaceans, arachnids, lizards and carrion.
[c]Vogel 2000. Animal matter includes opportunistic ingestion of snails.
[d]Ottenwalder 2000a.
[e]Wiewandt and Garcia 2000. Animal matter includes opportunistic ingestion of caterpillars.
[f]Buckner and Blair 2000b.
[g]Knapp 2000. Reference includes the observation that this species may be coprophagous.
[h]Iverson 2000. Animal matter includes opportunistic ingestion of crabs.
[i]Perera 2000. Animal matter includes opportunistic ingestion of crabs.
[j]Gerber 2000a. Animal matter includes opportunistic ingestion of land crabs and slow moving insect i.e. *Lepidopteran* larvae.
[k]Burton 2000. Other plant matter includes opportunistic ingestion of fungi. Animal matter includes opportunistic ingestion of crabs and cicadas.
[l]Mitchell 2000, Gerber 2000b. Animal matter includes opportunistic ingestion of some insects at a very low level (<1% of diet as consumed).
[m]Ottenwalder 2000b. Animal matter includes opportunistic ingestion of insects and crustaceans.
[n]Cyril et al. 2001. Hayes et al. 2004.
[o]No published data to date on this species.
[p]Day 2000. This report includes the observation that this species consumes plants that are toxic to birds and mammals.

Table 8 includes the nutrient analysis of plant parts consumed by some free ranging *Cyclura* spp. Dry matter content varied greatly with incomplete seed removal for some fruits, possibly resulting in higher values for many nutrients than those levels utilized by the iguana. However, though not completely digested by the iguana, parts such as seeds and skins of fruits, and undigestible leaf fractions probably play a role in maintaining integrity and health of the gastrointestinal tract by their physical form. These data suggest fruits consumed are low to moderate in protein, containing less than 9% protein on a dry matter basis (DMB), while leaves and flowers are moderate to good sources of protein at 9-17%, DMB. Though samples sizes are limited, and large variation exists, it appears flowers contained similar levels of protein and fiber as leaves.

Native plant food garden for headstarted iguanas in Anegada.

A wild *C. ricordii* feeds on a cactus fruit.

Tourists feed Allen Cays iguanas in the Bahamas. This practice is often detrimental to the health of wild iguanas.
Photo by John Iverson.

Table 8: Nutrient analysis on a dry matter (DM) basis of energy, protein, acid detergent fiber (ADF), neutral detergent fiber (NDF), fat, and ash of plants consumed by *Cyclura* spp.

Species	Part[1]	N	DM %	Energy Kcal/g	Protein %	ADF %	NDF %	Fat %	Ash %
C. c. carinata[2]	Fr	7	na	4.6± 0.5	na	na	na	na	na
	L	10	na	4.4± 0.2	na	na	na	na	na
C. collei[3]	Fr	5	34.9± 18.0	na	5.8± 2.7	40.5± 20.8	40.3± 16.4	na	na
	Fl	2	23.4± 6.8	na	12.3± 5.4	40.5± 27.6	25.6± 8.0	na	na
	L	4	58.5± 13.8	na	16.2± 3.1	20.3± 8.8	33.3± 14.2	na	na
	S	1	82.1	na	9.6	46.8	69.4	na	na
C. lewisi[4]	Fr	3	18.5± 7.3	na	4.5± 2.7	19.8± 6.3	23.6± 8.8	2.5± 1.9	10.4± 3.1
	Fl	5	15.7± 4.5	na	16.8± 6.5	21.3± 5.6	31.2± 9.4	3.5± 1.4	7.3± 2.7
	L	8	17.1± 5.1	na	16.5± 4.4	27.0± 7.8	36.8± 6.0	3.6± 1.5	16.6± 12.4
	W	11	23.6± 12.5	na	15.5± 6.1	24.0± 9.2	37.6± 10.9	3.5± 2.0	16.4± 10.4
C. pinguis[5]	Fr	9	37.5± 11.7	na	8.8± 5.7	35.1± 11.3	40.7± 15.0	5.0± 5.1	na
	Fl	6	50.9± 26.8	na	9.0± 3.4	38.0± 13.8	51.5± 22.3	5.5± 6.9	na
	L	16	39.0± 12.9	na	10.3± 4.4	22.5± 8.6	30.4± 10.5	4.6± 2.6	na

[1]Plant parts: flowers (Fl), fruit (Fr), leaves (L), whole plant (W), seeds (S).
[2]Auffenberg 1982
[3]A.M. Ward and J.L. Dempsey, 1998, unpublished data. Note seeds were not removed from the fruits prior to analysis.
[4]A.M. Ward and J.L. Dempsey, 2005, 2006, unpublished data. Note all seeds were removed from the fruits prior to analysis.
[5]A.M. Ward and J.L. Dempsey, 2006 unpublished data. Note most seeds were removed from the fruits prior to analysis.

Gastrointestinal tract characteristics in relation to diet

The gastrointestinal tract of those *Cyclura* spp. examined, indicate they have a capacious hind gut adapted for their primarily herbivorous diet (Iverson 1982). The hindgut is distinctive with several valves in the colon to slow passage rate and increase surface area. *C. c. figginsi* and *C. cornuta* have the largest number of valves in their hindgut of those *Cyclura* examined. These species also have few, if any, field reports of opportunistic ingestion of animal material. Similar to other herbivorous animals, these gut adaptations, in part, facilitate a symbiotic relationship with a microbial population within the gut. A significant benefit of this relationship is the production of volatile fatty acids by the microbes which can be absorbed by the host providing a significant source of energy. Few data exist specific to *Cyclura* spp. Baer (2003) provided a comprehensive review of adaptations to herbivory, including important dietary components, digestion, microbial contributions and fermentation in green iguanas (*I. iguana*) that should provide a base for understanding the primarily herbivorous species of *Cyclura*.

Diet survey

A summary of survey results is reported in Appendix Table G. The responses in general are subjective, which precludes determining nutrient levels offered and consumed.

Standard dietary protocol at ICR, Zoological Society of San Diego
Prepared by Jeff Lemm and the Nutritional Services Department, Zoological Society of San Diego

A large *C. n. nubila* feeds from a dish. Adult animals should be fed daily and will eat as much as 1,000 grams of food a day.

Some of the standard CRES dietary items.

Dishes should always be used to keep substrates out of food. Because sand can possibly cause gut impactions, the dish of this *C. collei* is elevated off the substrate with a plastic platform.

Hatchling iguana food should be finely chopped. Some species of iguanas can be kept in large groups without any major difficulties. This group of *C. n. nubila* was one of the first to test the theory of headstarting.

Animals are fed on a daily basis, Monday through Friday, with fresh water available in water dishes at all times. When possible, animals should be fed seven days a week and at ICR browse is often over the weekend. Dishes should be used for food so that substrates, which may be responsible for gut impactions, do not mix with the food. One dish is given per animal and each animal receives a single food dish, even when housed in pairs. Paired animals will sometimes fight over food, so it may be necessary to provide a small wall of cinder blocks or some other device as a visual barrier between dishes when animals are feeding. Hatchling animals may share a large dish; however, in cases where a larger, dominant animal chases subordinates from the feeding area, the smaller animal should be moved or provided with another dish. Greens are chopped according to the size of the animals being fed. Adults are fed chopped greens measuring about 3 in x 3 in (7.6 cm x 7.6 cm). Hatchling animals are fed finely chopped greens, measuring roughly .25 in x .25 in (0.63 cm x 0.63 cm). Juveniles are fed greens chopped to a size of 1 in x 1 in (2.54 cm x 2.54 cm). Fruits and vegetables are finely grated and mixed in with the other dietary items (fruits are usually cut and have had all seeds and cores removed before grating). It is important to mix the food well so that the animals cannot easily pick out the favored foods. The dry portion of the diet is a 50:50 mix of High fiber herbivore pellet, ZSSD specifications (more commonly known as ADF25) and Leaf eater food from Marion Zoological. Our high fiber mix is used not only as a supplement, but to avoid loose stools, as fresh greens can cause this ailment. The fiber is mixed with water, but if fecal deposits are still loose, the amount of water can be decreased until the stools are more firm. Sometimes it is necessary to eliminate the water in the mix, and in these cases, the grated fruits and vegetables are mixed directly in with the fiber diet, then added to the greens and mixed. At ICR we offer an in-house omnivore gel mix that provides a small amount of animal protein. *I. delicatissima* was fed this dietary supplement as well, with no ill-effects. On occasion, insects such as crickets have been fed to hatchling *Cyclura*, while some institutions offer pinky or fuzzy mice to their animals on rare occasions. All taxa of *Cyclura* are known to feed on some animal protein and some species have been seen feeding on hatchlings of their own species, birds, crabs, insects and other animals. It should be noted that wild *Cyclura* feed predominately on vegetation and very little is understood about animal proteins in their diet. Too much animal protein is believed to cause serious health problems. On some days of the week, especially in the spring and summer, browse plants, usually *Hibiscus* and *Ficus*, as well as Mulberry, are offered to the iguanas. These are simply freshly cut branches that are placed in PVC "vases" that hold water in the bottom. The "vase" is bolted to the walls of the enclosure and the branches are placed inside of them. All iguanas, including hatchlings, will feed on the leaves, flowers, and fruits of the plants. Some potted plants are kept in the enclosures and when the leaves are sufficiently browsed clean, the plant is replaced with a fresh one.

C. lewisi, like all rock iguanas whose diet has been studied in depth, very occasionally feeds on carrion like this freshly deceased dove, and slow-moving invertebrates such as slugs, caterpillars, and crabs. However, this forms an irregular and extremely small proportion of the overall diet, which is best described as a generalist herbivore diet (for which the rock iguana gut is highly specialized).
Photo by J. Binns.

Evidence of animal protein in wild iguana diets: Top left to right: insects and crabs (*C. pinguis*); Bottom left to right: fish and birds found near the burrows of *C. c. carinata*.

Some *Cyclura*, such as this Turks and Caicos iguana (*C. c. carinata*) have been known to eat hatchlings of their own species.
Photo by Joe Burgess.

Captive *Cyclura* such as this *C. pinguis* readily feed on browse plants. This *Hibiscus* branch is set in a PVC "vase" that holds water and is attached to the enclosure wall.

<u>Standard daily diet for one adult iguana at ICR</u>

Item	Weight	Day
Collard greens	125.0 grams	MWF
Mustard greens	125.0 grams	MWF
Chard	125.0 grams	MWF
Dandelion greens	125.0 grams	MTWThF
Kale	125.0 grams	TTh
Bok Choy	125.0 grams	TTh
Escarole	125.0 grams	TTh
Root vegetable (variable types)	15.0 grams	MTWThF
Squash (variable types)	15.0 grams	MWF
Green beans (chopped)	15.0 grams	TTh
Fruit (variable types)	15.0 grams	MTWThF
High fiber diet, ground, 1:1 by weight	35.0 grams	MTWThF
Water (mixed with fiber diet)	30.0 grams	MTWThF
Reptile carnivore/Omnivore gel	25.0 grams	MWF

<u>ZSSD Reptile carnivore/omnivore gel</u> <u>(adapted from information provided by the Tennessee Aquarium)</u>

Components:

1. Turtle Brittle (Nasco International, Inc., 901 Janesville Ave., P.O. Box 902, Ft. Atkinson, WI 53538)

2. Leafeater Diet (Marion Zoological, Inc., 13803 Industrial Park Blvd., Plymouth, MN 55441)

3. Gelatin (dry, unsweetened)

4. Carrots, raw

5. Greens, raw (kale, collard, dandelion, mustard)

Preparation (1 kg gel):

<u>Carnivore/Omnivore Gel</u> :

200 g Nasco turtle brittle (ground)

45 g Knox gelatin

90 g chopped leafy greens

90 g chopped/grated carrot

575 g hot water

1. Add prepared greens and carrots to high power blender, followed by all dry ingredients.

2. Add hot water to blender. Immediately homogenize all ingredients for 3 min. Mixture should be a thick liquid.

3. Pour into a shallow pan and allow gel to set in refrigerator. Cut gel with a knife or food processor to obtain appropriately sized pieces. Feed free choice as the primary diet; consumption will vary by species. Remove uneaten gel on a daily basis.

4. Additional items can be added to gels: mealworms, extra chopped fruits and/or vegetables, crushed limestone or oyster shell for mollusc eaters. Gels can also be used as a vehicle for medications.

5. Keep gel refrigerated and use within seven days. Gel can be frozen, stored in an airtight container, for up to three months.

Selected nutrient analysis of omnivore/reptile gel (dry matter basis, except moisture)

Nutrient	Carnivore/Omnivore gel
Mositure (%)	75.4
Crude protein (%)	53.7
Crude fat (%)	5.2
Ash (%)	10.0
Crude fiber (%)	2.6
Calcium (%)	1.7
Phosphorus	1.3
Sodium (%)	1.0
Magnesium (%)	0.2
Iron (ppm)	251.6
Zinc (ppm)	83.5
Manganese (ppm)	10.7
Thiamin (ppm)	4.0
Riboflavin (ppm)	8.0
Vitamin B_{12} (ppb)	32.5
Niacin (ppm)	56
Vitamin A (IU/kg)	11356
Vitamin D (IU/kg)	4059
Vitamin E (IU/kg)	76.0

The following dietary protocol was adapted for hatchling Grand Cayman Blue iguanas (*C. lewisi*) from the above protocol. These young animals were brought from the breeding and headstart facility in Grand Cayman and within 30-60 days had some medical issues that were believed to be diet-related. The issues were resolved using this diet, by keeping the enclosures very humid, and by supplementation.

Standard daily diet for one subadult Grand Cayman iguana at ICR

Item	Weight	Day
Collard greens	60.0 grams	MWF
Mustard greens	60.0 grams	MWF
Chard	60.0 grams	MWF
Dandelion greens	60.0 grams	MTWThF
Kale	60.0 grams	TTh
Bok Choy	60.0 grams	TTh
Escarole	60.0 grams	TTh
Root vegetable (variable types)	7.5 grams	MTWThF
Squash (variable types)	7.5 grams	MWF
Green beans (chopped)	7.5 grams	TTh
Fruit (variable types)	7.5 grams	MTWThF
Miner-all ("O", without D_3)	1/8 teaspoon	MWF
Miner-all ("I", with D_3)	1/8 teaspoon on 1st and 15th of each month	

(Miner-all supplements from Sticky Tongue Farms/Miner-All, P.O Box 173, Sun City, CA 92586)

Health

By Nancy M. Lung

Introduction

For the past 15 years there has been intensive focus on the conservation and biology of species in the genus *Cyclura*. Prior to that time it was necessary to extrapolate from what is known from other iguanids (primarily the green iguana) and reptiles in general when faced with medical and husbandry issues. What has been learned about these taxa of lizards over the past 15 years greatly increases our knowledge of and resources for the health management of this group.

The medical section of this husbandry manual will summarize the medical issues facing *Cyclura* in captivity, will review the medical data that have been collected from free-ranging *Cyclura* as well as those housed in headstart facilities in range countries, and will provide resources that can be utilized by personnel responsible for the health management of *Cyclura*. The data presented in this chapter were tabulated in December 2005. Note that some of the sample sizes are small. The database will be continually updated as more health evaluations are performed on *Cyclura*.

Medical management of captive iguanas (zoological and private collections)

Captive *Cyclura* are maintained under a variety of conditions in zoos, breeding centers, and private collections. In order to maintain good health and achieve reproductive success there are environmental, nutritional, and social needs that must be met, as delineated in other sections of this manual. Good preventive health programs must start by ensuring that these basic needs are met. Following that, knowledge of the common medical conditions seen in *Cyclura* will help holding institutions design preventive health programs specific to their collection.

A survey of medical records of captive *Cyclura* was conducted to identify the reasons for medical intervention with these animals in captivity. The following table summarizes the data from this survey. Health issues are then discussed in descending order of prevalence.

Results of medical survey of *Cyclura* holding institutions

Number of zoos responding	28
Number of animal records reviewed	380
C. cornuta cornuta	188
C. cornuta stejnegeri	3
C. nubila nubila	91
C. lewisi	66
C. pinguis	8
C. cychlura figginsi	7
C. collei	12
C. *ricordi*	5
Number of medical or necropsy entries	978
Trauma	118
Parasites	114
Infections	89
Reproductive events	50
Renal failure	34
Calcium/vitamin D related problems	32
Anorexia/lethargy	22
Intestinal impaction	10
Hypothermia	9
Burns	7
Cystic calculi	1

Trauma

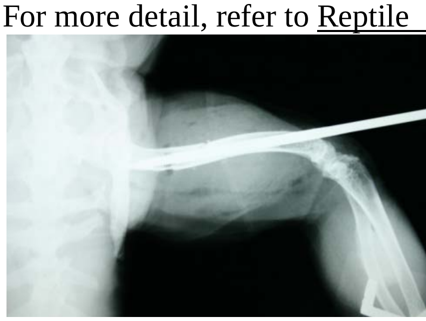
The most common medical problem seen in captive iguanas is trauma. Trauma is most commonly induced by conspecifics during aggressive social encounters, but can also occur due to injuries in exhibits and holding areas, or during capture and handling. Overcrowding increases the incidence of conspecific aggression. A keeper with keen observation skills will identify groupings at risk for aggression and will re-adjust the group composition toward more compatible individuals.

This male Jamaican iguana suffered a degloving injury on both sides of his face during a conflict with another adult male. Photo on the right shows a close- up of the injury with the underlying facial muscles exposed.

Lacerations from bite wounds are common. If they are attended to the same day, lacerations can be cleaned and sutured, giving the best outcome. Wounds that are identified more than several hours after occurrence need to be managed as open wounds. This involves thorough cleaning and debridement, as it is common for the wounds to be packed with dirt and other exhibit materials. Systemic antibiotics should be used to control infection at the site of the injury. Wounds should be monitored closely, as many develop complications such as abscessation, or necrosis of digits or tails. Subsequent amputation of digits, limbs, and tails may be necessary due to infection or loss of blood supply.

Loss of nails, digits, and tail tips is a common consequence of traumatic injuries in iguana.

Long bone, vertebral and jaw fractures can also occur during trauma. The risk is increased in animals with suboptimal vitamin D and calcium status. Long-bone fractures can be repaired with external splints, external pins or internal fixation devices. For more detail, refer to Reptile Mader (2006).



Repair of a femoral fracture using an intramedullary pin in a Grand Cayman Blue iguana.
Photo: J. Ramer

Parasitology

Parasites account for the second most frequently encountered medical event in captive iguanas and are also seen in free-ranging animals. However, most of the parasites are benign and have not caused clinical problems in otherwise healthy animals. Any parasite can contribute to health problems if animals are at suboptimal weight, physiologically challenged (i.e., gravid or sick), or under environmental stress. In animals maintained on natural substrates, parasite levels can build up in the environment, leading to superinfections and rapid reinfection after treatment. Good hygiene practices and daily removal of fecal material will help with this problem and reduce the need for antihelmintic treatment.

Ticks and mites are the most common ectoparasites. Ticks will attach to the host in a variety of locations, but prefer the more hidden regions of axillary and inguinal regions, in the folds of the cloaca, and occasionally on the neck and face. Ticks can be easily missed if the physical exam is not thorough. Ticks rarely cause medical problems for the iguana, though ticks are capable of transmitting blood parasites and viruses. When found they should be removed. Physical removal using forceps is appropriate for low-level infestation. For higher levels of infestation ticks can be treated topically with a permethrin-based acaracide such as Provent-a-Mite™ (Pro Products, Mahopac, NY) or systemically with ivermectin at a dose of 200mcg/kg body weight.

Mites are a common ectoparasite of captive iguanas. Like ticks, the mites prefer folds of skin and can often be seen as red, grey or black dots around the skin folds of the eyes, neck, cloaca, and limbs. Treatment for mites is the same as noted for ticks—using a permethrin product topically or ivermectin systemically. Environmental control is as important as treatment of the animal and can be done with a cyfluthrin-based premise spray such as Tempo® (Bayer Corporation, Kansas City, MO)

External mites identified on a Jamaican iguana at the headstart facility in Kingston.
Photo: W. Marsden

Endoparasites are diagnosed by fecal exam. Fecal flotation will identify a variety of nematodes (such as pinworms), some cestodes (tapeworms), and some protozoa (including coccidia). A fecal sedimentation is less commonly performed, but is necessary for identifying trematodes. A direct microscopic exam from a fresh sample is used to identify motile protozoa such as ciliates and flagellates. Motile protozoa are generally harmless and are expected to be present in the hindgut of most lizards. A fecal cytology can be performed to identify potentially harmful amoeba.

The most common nematode in captive, headstart, and free-ranging *Cyclura* are pinworms (oxyurids). These are generally non-pathogenic, though they can be seen in very large numbers. Treatment of oxyurids with antihelmintics is controversial. Some parasitologists believe that oxyurids can play a beneficial role in breaking up dry vegetation in the hindgut of the iguana (E. Greiner, pers. comm.; Iverson 1982). Oxyurids are not susceptible to standard doses of antihelmintics such as fenbendazole, pyrantal and ivermectin. Successful treatment requires high doses of drugs given repeatedly, which raises the threat of doing more harm than good when trying to treat pinworms. This dilemma can be avoided by reducing the rate of superinfection through good enclosure hygiene practices, periodic substrate replacement and daily removal of fecal material.

Oxyurid ova from *Cyclura* fecal flotation.
190 x 171µm, 160x
Photo: E. Greiner

Protozoa, including coccidia and *Entamoeba*, can be responsible for significant morbidity, including poor weight gains or weight loss, enteritis and malabsorption. Coccidia can be a frustrating problem in reptile hatchlings housed in high density, though specifically in *Cyclura* facilities this problem has not been identified. Good husbandry practices are the first line of defense. Clinical cases can be treated with sulfa-based coccidiastats such as sulfadimethoxine. Such treatment will reduce the load of coccidia and improve the health of the iguana, but is unlikely to eliminate the infection. The drug ponazuril has shown potential to clear coccidial infections in mammalian species. Its safety and efficacy in lizards has not been evaluated. Good husbandry is the answer to this disease problem.

Entamoebiasis is not a common disease in lizards, but when it occurs it is often fatal. Signs include anorexia, dehydration, and wasting. Bloody diarrhea can be seen, but the animals are often found dead before this clinical sign is manifested. Lizards are at increased risk of infection when they are housed in close proximity to snakes and chelonians or when transferred between collections. Pre-mortem diagnosis can be difficult. Finding the amoeba on fecal cytology can be helpful, but false negatives are common. Diagnosis can be made from histopathology of a necropsy specimen. Therefore, if amoebiasis is suspected, treatment should be initiated as early as possible. Metronidazole, iodiquinol, and paromomycin have all been used successfully. Combination therapy is ideal. Systemic antibiotics to treat concurrent septicemia are often required. When a diagnosis is made by histopathology, special attention should be given to other animals in the group.

Cryptosporidium has rarely, if ever, been found in captive or free-ranging *Cyclura* spp. Its capacity to cause disease in this group of lizards is not known.

Infections

The third most common reason for veterinary intervention with captive *Cyclura* is infectious disease. These are predominantly bacterial infections involving abscesses, pneumonia, and septicemia. Viral infections are rarely diagnosed in lizards. Fungal infections can be seen, but are much less common than invasion with opportunistic pathogenic bacteria.

Although the incidence of bacterial infection is very high, this is misleading. Animals kept in optimal housing and nutritional conditions rarely develop primary bacterial infections. However, other primary diseases such as those affecting the liver, heart, or genitor-urinary system often go undetected, leading to debilitation and reduced immune function in the animal. The bacteria that ultimately kill the iguana are usually opportunistic invaders. A clinical or post-mortem evaluation that detects a bacterial infection should be backed up with a thorough evaluation of underlying pathology.

The majority of bacterial pathogens in iguana are gram negative rods such as *Pseudomonas* and *Salmonella*, though numerous bacterial species have been cultured from diseased iguanas including *Proteus, Neisseria, serratia, E. coli,* and others. Broad spectrum antibiotic coverage should include drugs that are effective against *Pseudomonas*, which include enrofloxacin (Baytril), aminoglycosides (amikacin or gentamycin), and third generation cephalosporins such as ceftazidime (Fortaz). When a *Pseudomonas* infection is confirmed by culture, antibiotic sensitivity testing must be done since drug resistance in this bacterium is common. Combination therapy using two of the three drugs listed will be more effective against *Pseudomonas* and any of the drugs alone. When antibiotic therapy is initiated prior to bacterial culture results, broad spectrum coverage that includes gram negative, gram positive, and anaerobic bacteria is appropriate.

Reproduction

Reproductive disease in captive *Cyclura* is common and represents some of the most life-threatening conditions seen. The husbandry and nutrition of captive *Cyclura* have improved in recent years as we learn more about the normal biology of this group of animals. However, nutrition and husbandry-related problems probably still contribute significantly to the high incidence of reproductive complications. There is still more to learn.

Cyclura are oviparous lizards, producing a single clutch of pliable eggs each year. In the wild, *Cyclura* folliculogenesis begins in March. Nesting behavior usually begins in late May to early June, with eggs laid in deep-tunneled nests in June to early July. These times may vary in more northern captive settings. Animals undergoing folliculogenesis should have very high circulating calcium, phosphorus, cholesterol and triglyceride levels. The presence of these biochemical variations is a reliable indicator that a female is in an active reproductive state. It is important to not interpret these values as abnormal when evaluating the serum chemistry results of a female iguana during the reproductive season. For example, normal, non-reproductive serum calcium in a healthy iguana should be approximately 12 mg/dl, but can exceed 150 mg/dl in a reproductively active female (see table below). The numbers are remarkable and should be interpreted in light of the gender and reproductive status of the animal.

	Calcium (mg/dl)	Phosphorus (mg/dl)	Cholesterol (mg/dl)	Triglycerides (mg/dl)
non-reproductive	12	6	85	115
undergoing folliculogenesis	can be > 150	can be > 16	can be > 280	can be > 700

It is common for female iguanas to go off feed during the weeks leading up to oviposition, to lose condition, and to look “spent” after a clutch has been laid. Throughout the period of anorexia their attitude and nesting behavior should remain normal. A healthy female will rebound quickly and replace the lost body condition. An anorexic female that becomes lethargic or fails to lay her eggs in a normal window of time should receive medical intervention.

Reproductive complications reported in *Cyclura* include infections of the ovary and oviduct (oophoritis and salpingitis), failure to ovulate (follicular stasis, follicle binding), egg yolk peritonitis (coelomitis), failure to pass eggs (egg binding or dystocia), hemipene and oviductal prolapses, and neoplasia. All of these conditions are life-threatening and require skilled medical intervention. Diagnostic evaluation should include complete physical exam and review of reproductive, husbandry and weight history, complete blood count and serum chemistry profile, coelomic ultrasound, and whole body radiographs. Care should be taken when performing a diagnostic evaluation on a female undergoing folliculogenesis, as manual restraint creates a risk of a follicle rupture leading to yolk peritonitis. A safe technique for handling involves luring the animal into a tube such as a PVC pipe, closing the ends, and administering isoflurane anesthesia into the tube. The iguana will relax and can be handled with less of a struggle.

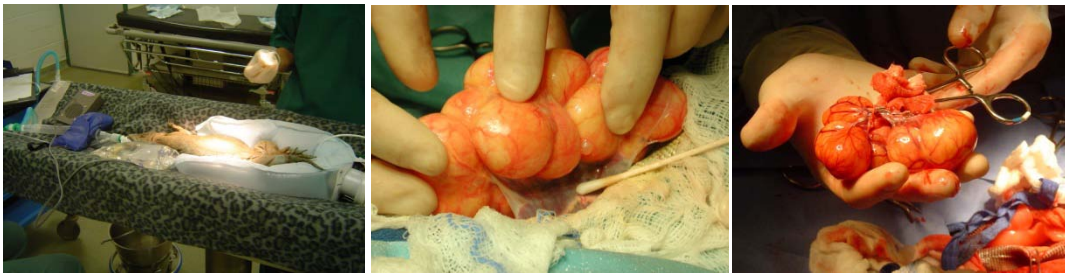
Ultrasound is used to evaluate the status of the ovary and to follow the process of folliculogenesis. Once the follicles have ovulated and been shelled, radiographs can be used to confirm the presence and number of eggs and to determine if there is any physical obstruction preventing egg passage.

Left: Radiograph of female Jamaican iguana with follicles evident on radiographs.
Right: Radiograph of female Jamaican iguana, gravid with infertile, mis-shapen eggs.

Oophoritis and salpingitis can be difficult to diagnose pre-mortem. Suspicion is high if the animal is reproductively active and if clinical and laboratory data support sepsis. Treatment should include broad spectrum antibiotic coverage. Combination drug therapy is preferred. Husbandry and temperature conditions should be optimized. Fluid and nutritional support should be provided.

Follicular stasis is a common problem in green iguanas and has been seen in captive *Cyclura*. In this condition the follicles develop normally but fail to ovulate. The mechanism of this is unknown, but likely relates to subtle environmental or nutritional issues that are not optimized in the captive setting. Diagnosis is made by ultrasound exam, documenting a follicular phase that began at a normal time, but has progressed past when normal ovulation should have occurred. Radiographs can be used to confirm that there are no shelled eggs present. Hormone therapy to stimulate ovulation has not proven useful. Occasionally reptiles will resorb the yolk of unovulated follicles. However, the presence of the retained yolk predisposes the animal to ovarian infection, yolk emboli and yolk coelomitis, all of which have a poor prognosis for recovery. Surgical intervention to remove the ovaries is the best life-saving option and must be considered even though it removes that animal from the breeding population.

The pictures below show a surgical correction for follicular stasis. Note the ovarian pedicle that needs to be ligated (suture and ligaclips both work well). The pedicle of the right ovary is closely associated with the vena cava and the pedicle of the left ovary is in close proximity to the adrenal gland. Care must be taken to avoid accidental damage to the adrenal gland and local blood vessels during this surgery.



Ovariectomy in a Jamaican iguana with chronic follicular stasis. The left shows the anesthesia and surgical set up for a ventral paramedian approach. The middle shows the follicle-rich ovary being gently exteriorized, exposing the close proximity of the ovarian stump to the adrenal gland. The right shows the ovary in hand after surgical removal.
Photos: S. Ferrell

Dystocia is a condition where eggs fail to pass at the appropriate time. Sometimes a female is actively pushing and no eggs are being passed. These cases are easy to diagnose. More typically a female will show weak to moderate nesting behavior over a period of time, and fail to lay eggs. The first intervention is to make sure that the nesting environment and temperature are ideal. Many dystocias occur because the female does not have all of the environmental conditions necessary to trigger the normal laying process. When medical intervention is elected, be sure to evaluate the whole patient and rule out concurrent disease or physical obstruction. Correct those problems as necessary. When the animal is in good condition and well hydrated, dystocia can be corrected using oxytocin (published doses range from 1-30 IU/kg body weight). Best results are achieved when a second dose is given 45-90 minutes after the first. A percentage of dystocias that are refractory to oxytocin therapy can be reduced using arginine vasoticin, a more specific reproductive hormone in reptiles. This drug is experimental and expensive, but should be considered if oxytocin fails.

When hormone therapy fails to correct a dystocia, surgical intervention is a good option. If the reproductive capability of the female can be sacrificed, then removing the ovaries is the most efficient surgical approach and will eliminate future reproductive complications. If the reproductive status needs to be preserved, then multiple small incisions in the oviducts will be necessary to remove the numerous eggs. If the animal is otherwise healthy and the reproductive tract is free of infection, the iguana should retain normal reproductive capability.

Yolk coelomitis occurs when yolk material leaks from a follicle and becomes free in the coelom. The animal's body treats the yolk as foreign material, generating a significant inflammatory response. The prognosis in these cases is poor. Animals that survive have a poor reproductive future. Treatment should include supportive care appropriate for sepsis, antibiotic and anti-inflammatory therapy, and possible surgical flushing of the coelom.

Hemipene prolapse generally occurs following breeding activity in the male iguana. In the female, oviductal prolapse can occur during egg laying. The principles of prolapse management are similar for both cases. The earlier the intervention, the better. The tissue needs to be kept moist, clean, and protected until it can be replaced to its normal position. General anesthesia is usually required to facilitate adequate relaxation. With gentle tissue handling and patience prolapses can usually be reduced. Appropriate antibiotic coverage should be provided and the animal should be observed for recurrence. If the prolapsed tissue is necrotic, surgical removal will be necessary.

Preventive medicine is the key to healthy reproductive tracts in reptiles. We need to learn more about the normal biology of these animals, using that information to perfect our husbandry practices. We need to closely monitor vitamin D and calcium status, maintain optimal temperature ranges and photoperiods, and provide ideal nesting environments. Until all of these variables are controlled we can expect continued reproductive problems in captive *Cyclura*.

Renal Disease

Iguanas have paired kidneys that are located deep in the pelvic canal. This anatomic location makes the normal iguana kidney difficult to evaluate by palpation, radiology, or ultrasound. Renal disease is common in iguanas and can result in frustrating clinical cases. Chronic renal disease may be suspected with patients that show, slow, chronic demise, poor body condition, anorexia, and lethargy. Acute renal failure may be suspected in an animal with excellent, robust state with acute lethargy and anorexia and reduced urine output.

Chronic renal disease may occur secondary to dietary problems such as high protein diets, inadequate humidity resulting in chronic subclinical dehydration, hypervitaminosis D as occurs with over-zealous treatment with injectable vitamin D, and chronic infections. Acute renal failure can occur from a toxic insult such as nephrotoxic plants or improper use of nephrotoxic drugs such as amikacin and gentamycin. A bacterial infection of the kidney has the potential to cause acute renal disease. Kidneys that are not functioning properly will fail to clear uric acid from the blood, resulting in the accumulation of urates in and on the kidneys and on the surface of other organs (visceral gout).

Complete blood count and serum chemistry analysis should be performed when evaluating an iguana with suspected renal disease. However, there are limitations to the utility of blood results in these cases. Creatinine and BUN are not helpful in evaluating renal function since the nitrogenous waste product of the iguana is uric acid, not urea. In acute renal failure the uric acid can be quite elevated, resulting in acute visceral gout due to precipitation of the uric acid crystals on organ surfaces. In chronic renal failure the serum uric acid is often normal to slightly elevated. However, other changes such as anemia and elevated phosphorus can raise the suspicion of renal disease. Evaluation of serum electrolytes is of limited value in cases of renal disease since the iguana regulates electrolytes through a number of organs, including the kidneys, nasal salt gland, cloaca, colon, and urinary bladder.

The best diagnostic tool for evaluating renal health in the iguana is a renal biopsy. Several techniques have been described for safely accessing the intrapelvic iguana kidney. For a review of the techniques see Reptile Medicine and Surgery, second edition, chapter 66.

Calcium/Vitamin D Related Problems

Maintenance of calcium and vitamin D homeostasis in *Cyclura* in the captive setting has been difficult in many species in many institutions. Despite improvements in husbandry and nutrition, this problem is stubbornly persistent and likely contributes to a number of secondary health problems in captive *Cyclura*, including poor reproductive success, metabolic bone disease, orthopedic fractures and hypocalcemic tetany A broad review of husbandry practices at holding institutions would be needed to tease out the issues that result in hypocalcemia and hypovitaminosis D. Until such a review is done we work with anecdotal information.

Captive *Cyclura* in zoos generally have lower plasma vitamin D_3 levels than their wild and headstart counterparts. This likely results from inadequate exposure to natural ultraviolet light in indoor enclosures and inadequate wavelength, distance, and duration of exposure to artificial ultraviolet light. Even in completely outdoor enclosures, such as those in many headstart facilities, plasma vitamin D levels decline when natural vegetation shades the enclosure, reducing direct sunlight. It is important to keep trees and vines trimmed back and ensure direct sunlight to part of each outdoor area. Also be cognizant of competition for basking spots in group housing situations as some individuals can be out-competed for access to direct sunlight.

Plasma vitamin D levels can be found in the normal blood values table. Note that the reported values for 25-OH D_3 and are in ng/ml. This is important since some labor atories measure vitamin D in ng/ml, while others measure in umol/L. The two are not interchangeable, so the units must be considered when interpreting results for plasma vitamin D. See the Nutrition section of this manual for information on the use of artificial UV in indoor enclosures.

Intestinal impaction

Intestinal impaction in *Cyclura* has been recorded in at least 10 animals. Impaction can occur after ingestion of a large foreign body. However, impaction is more common as a result of sand/grit ingestion during feeding/foraging. Sand impactions will usually present as anorexia and lethargy with reduced fecal output. Straining to defecate is not always present. Intestinal impaction can also result secondary to colonic compression from a dystocia or urinary calculus. Radiographs should be used to evaluate the underlying cause of an impaction and treatment initiated accordingly.

Cystic calculi

Iguanas have a fully developed urinary bladder that is fed by a ureter from each kidney, and drained by a single urethra that empties at the urodeum in the cloaca. Bladder stones, or cystic calculi, are a common medical problem in iguanas as they are in many orders of reptiles. They have been seen in *Cyclura* in zoos as well as in headstart facilities. The etiology is poorly understood but is likely multifactorial including nutrition (vitamin, mineral, and moisture content of the diets), humidity, and chronic low-grade dehydration, and possibly urinary tract infections. When a cystic calculus is identified it should be surgically removed. Untreated stones can lead to trauma to the bladder wall, urinary infections, urinary obstruction, egg binding, and fecal retention.

Diagnosis is made through coelomic palpation and radiography. Larger stones are easily palpated in the caudal coelom. Urate stones can be radiolucent. However, the chemical makeup of these stones is quite variable and there is usually enough mineral content in the stone to make it radiodense.

Radiograph of a Jamaican iguana with a bladder stone.

Surgical removal of the stone involves a straightforward cystotomy using a ventral paramedian approach—similar to that used for ovariectomy but somewhat more caudal. Chemical analysis of the stone is recommended to add to our knowledge of this disease process. Maintain adequate hydration and broad-spectrum antibiotic coverage. Recovery should be uneventful.

Surgery to remove the stone is shone—first with the bladder intact (left), second with the bladder incised and the stone being gently extracted (right).
Photos courtesy of S. Ferrell

Idiopathic leukocytosis

In recent years one zoological institution has dealt with an unusual leukocytosis (elevated white blood cell count) in their Jamaican iguana population. Both male and female iguanas are affected. White blood cell counts can be as high as 72,000/ml and is usually detected during a routine exam. The animals are clinically normal. White blood cell counts have returned to normal with antibiotic therapy, but others have returned to normal without any treatment. There does not appear to be a seasonality to the high cell counts and the Grand Cayman Blue and Rhino iguana housed at the same facility under similar husbandry conditions are unaffected. The cause of the periodic leukocytosis remains a mystery.

Clinical techniques

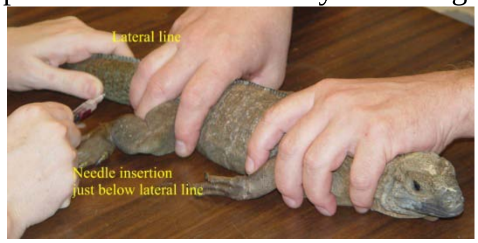
<u>Blood collection</u>

For most laboratory analysis (complete blood count, blood chemistry, nutritional analysis such as vitamin D) a "green top" or lithium heparin blood tube should be used. The lithium heparin will keep the blood sample from clotting and will not interfere with any of the laboratory assays. If you are unsure of a laboratory requirement for blood collection, consult the laboratory prior to drawing the sample.

A reliable measure of how much blood can safely be collected from a lizard is an upper limit of 0.7 to 1% of the animal's body weight. For example, from a 100 gm animal, one can collect 0.7 to 1 gm of blood, which is equivalent to 0.7 to 1 ml of blood. This calculation is important when working with hatchling and juvenile iguanas, since many laboratory blood tests require at least 1ml of blood for analysis. Be careful not to over-collect blood volume. Some laboratories have equipment for working with small sample volumes while others do not. And only a handful of laboratories are skilled with reptilian blood. Do some homework and develop a good working relationship with a skilled laboratory. A good lab can run a full CBC and chemistry from 0.5 ml blood.

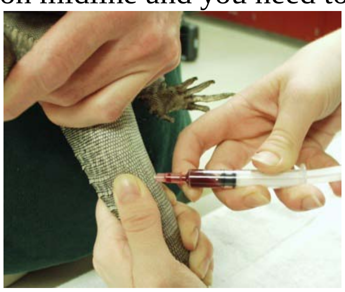
The most reliable site from which to collect blood from iguanid lizards is the ventral coccygeal vein. This vein runs on the midline of the tail just ventral to the vertebral bodies. To avoid potential damage to the hemipenes, this vein should be accessed a few inches distal to the cloaca. Both the lateral and ventral approaches are useful, though the lateral approach seems to be more successful in *Cyclura*.

For the lateral approach, set the animal in a normal resting position on the table with the handler controlling the head and pelvic region. Palpate the sides of the tail to identify the lateral aspect of the vertebral transverse processes (sometimes this can be seen as a small indentation on the tissue on the lateral side of the tail—similar to a lateral line in a fish). Prep the area with alcohol to remove dirt and debris. Go two to three scales ventral to the lateral line and insert the needle perpendicular to the skin to a depth half the width of the tail. If the needle reaches bone then you are slightly too high and need to direct your needle slightly lower. If the needle goes past midline and has not penetrated the vein then you are slightly too low and need to aim a bit higher.



Lateral approach to blood draw from the ventral tail vein. Note the restraint and the positioning of the needle.

For the ventral approach, hold the animal upright or on its back with the ventral side facing the collector. The collector holds the tail to stabilize it. Using alcohol, prep a region a few inches distal to the cloaca. Insert the needle perpendicular to the vertebral column exactly on the midline. Advance the needle using slight negative pressure on the plunger until blood starts to flow or until the needle reaches bone. If the needle reaches bone then you have gone through the vein and need to back out slightly, or are not quite on midline and you need to redirect.



Ventral midline approach to blood collection.

Gavage feeding

Gavage feeding, or "stomach tubing" is a key method of providing support to an ill iguana. With experience it can be used repeatedly and with low stress to the animal and will improve the outcome of many difficult cases. Tubing is routinely used to provide oral medication to a stubborn or anorexic animal and to provide nutritional and fluid support to a sick/anorexic patient. This can also be used as a diagnostic tool for collecting samples of gastric contents.

Gavage feeding tools

Both flexible and rigid gavage tubes can be used successfully. Before starting the procedure estimate the distance from the mouth to the stomach so you have a target of how far in you will need to place the tube to reach the stomach. If the tube is not inserted far enough the infused solution is likely to reflux into the oral cavity, risking aspiration. If the tube is inserted too far, damage or perforation of the stomach wall can occur.

Both rigid and flexible tubes can be used in iguanas. A soft mouth speculum should be used to protect the teeth from being damaged when the animal bites down on the feeding tube.

Most iguanas during manual restraint will spontaneously open their mouth in defense/aggression. Take this opportunity to insert a soft coated speculum of some sort. Once an iguana closes its mouth tightly it is difficult to pry it open without risking injury to the animal or the handler, though gentle downward pressure on the dewlap can help get a stubborn mouth open. The soft coating on the speculum helps to protect the animal's teeth. Insert the feeding tube into the pharynx above or to the side of the glottis, which can be visualized just behind the tongue. Continue to advance the tube to the desired depth and infuse the product slowly. While infusing, watch for evidence of reflux. If reflux occurs, discontinue infusing, remove the tube, and put the animal down. Aspiration is more likely to happen when an animal is struggling during manual restraint. If the animal is put down with a mouth full of feeding material, it will relax and swallow normally or shake the material out of its mouth.

When gavage feeding is being done as one of several treatments during a manual restraint, do the other treatments first and the gavage last. This will reduce the incidence of regurgitation.

Tube feeding guidelines

Anorexia is a significant risk factor during a period of illness. Animals need calorie and nutrient intake for good immune function and convalescence. Self-feeding also facilitates administration of oral medications. Gavage feeding is recommended as part of the medical management of anorexic, ill iguanas. A safe rule of thumb is to feed no more than 1.5-2 % of the animal's body weight per feed. This equates to 15-20 gm of formula per kilogram of body weight.

Donoghue provides a good review of gavage feeding options in Mader's reptile medicine textbook. Commercially available products that give good clinical results include Ensure Plus (Ross Laboratories), Oxbow critical care for herbivores (Oxbow Hay Co, Murdock, Neb), and Enteral Herbivore (Nutrition Support Services, Pembroke, VA; availability of this product is becoming limited). A reasonable short-term home-made enteral formula is:

99.75 % vegetable baby food + 0.25 % ground up adult multi vitamin and mineral tablets (centrum or a generic centrum will work and should be available anywhere). The baby foods with the best calcium:phosphorus ratio include green beans, carrots, squash and garden vegetable. Baby foods to avoid due to a negative Ca:P ratio include peas, mixed vegetable, spinach, sweet potato and fruits, and any meat-based baby food. The energy density and consistency of this formula can be improved by adding ground up high-fiber monkey chow.

The calculation of how much formula is required comes from a general reptile equation for energy needs:

Kcals/day for standard metabolism = 32 X (body weight in kg)$^{0.75}$

For Enteral Herbivore it is 1.4 kcal/gram of formula.

For example, for a 2 kg iguana:

Kcals to feed for baseline metabolism = 32 x $2^{0.75}$ = 32 x 1.68 = 53.76 kcal

53.76 kcal ÷ 1.4 kcal/gm = 38.4 gm of formula per day. This is a manageable volume and may be divided into two feeds per day if needed.

(Nutrient analysis on a dry matter basis of the baby food formula: protein 22.4 %, fiber 14.6 %, fat 2.0 %, vit A 648.8 IU/g, vit D 6.5 IU/g, vit e 538.5 mg/kg, B1 30.3 ppm, ribo 34.4 ppm, niacin 401.2 ppm, B6 42.3 ppm, folic acid 10.4 ppm, B12 0.1 ppm, biotin 0.49 ppm, C 1532 ppm, ca 0.54 %, p 0.45 %, mg 0.4 %, K 1.8 %, na 0.3 %, fe 373.7 ppm, zn 269.3 pm, cu 39.4 ppm, mn 32.5 ppm, se 0.4 ppm, I 2.4 ppm.)

Cloacal swab

A cloacal swab can be used to collect a sample for bacterial culture, or to get fresh fecal material for cytology. The iguana can hold the cloaca tightly shut, so swabs must be inserted gently, ensuring not to push too hard and risk injury. Use one hand to gently spread the opening to the cloaca. Using the other hand insert a cotton-tipped applicator directly perpendicular to the tail for initial access. Sometimes it is necessary to direct slightly caudally into the vent to get initial access. Once the tip has passed into the opening, re-direct it in a forward direction to a depth of about an inch. Roll the cotton tip back and forth to ensure good mucosal contact, then slowly withdraw.

Passing sterile swabs into the cloaca for the collection of material for bacterial culture.

Euthanasia:

Euthanasia may be required in the management of captive *Cyclura* for a number of reasons, including alleviating suffering in critically ill animals, and culling non-viable hatchlings. Numerous techniques have been employed in the euthanasia of reptiles. However, many are inhumane and/or detrimental to good post-mortem evaluation. Physical methods of euthanasia include deep freezing, decapitation, and pithing through the parietal eye. All physical methods of euthanasia must be preceded by a surgical plane of anesthesia, which can be achieved through excessive doses of injectable anesthetics (telazol or ketamine) or through deep inhalant anesthesia using isoflurane.

The deep freeze method is not recommended as it results in a specimen that is of little use for post-mortem evaluation. Frozen tissues do not make good histopathology specimens.

The ideal method of euthanasia is achieved chemically using either potassium chloride or a barbiturate solution. These should be administered intravenously or intracoelomically **after** a surgical plane of anesthesia has been reached as described above.

For more information on this issue, see the guidelines from the American Veterinary Medical Association Panel on Euthanasia.

Health of free ranging and head started West Indian Rock iguanas

Comprehensive health evaluations have been conducted on most species of West Indian Rock iguana. From these health programs a database has been established which includes normal blood values, internal and external parasites, normal gastrointestinal bacterial flora, common health problems, growth rates, and nutrition. Such data are useful in the management of the all of the *Cyclura* conservation programs. And the data provide much needed reference information from which we can improve the medical management of iguanas in head start facilities, zoos and private collections.

Health assessments of iguanas in the "field" include free-ranging iguanas as well as animals housed in headstart facilities located in range countries. Health assessments performed in the field include:

- Physical examination of each specimen
- Body weight, standard measurements, and growth data for each specimen (when available)
- Collection of whole blood for genetic analysis, white blood cell counts and differentials, screening for blood parasites, and measurement of hematocrit and total solids.
- Collection of plasma for measurement of plasma biochemical parameters.
- Cloacal swabs for bacterial culture for assessment of normal intestinal bacterial flora and to screen for bacterial pathogens.
- Collection of feces for assessment of intestinal parasite burdens.

Dr. Robarto Maria determines gender on a free-ranging Ricord's iguana in the Dominican Republic.
Photo by J. Ramer

Health assessments of iguanas in range countries pose unique challenges for each species. For example, with the Jamaican and Grand Cayman iguana conservation programs, there is good infrastructure and support for the headstart facilities, but access to free-ranging animals has been infrequent and unpredictable. This results in a database that is rich in headstart data, but poor in data from free-ranging animals. When wild iguanas are caught in the Hellshire Hills of Jamaica it is generally during the nesting season, skewing the data toward reproductively active females. For the San Salvador iguana all health assessments were performed at a single time point from a single free-ranging population. This will add some bias to the data and must be interpreted accordingly. Similar challenges exist in the evaluation of the other *Cyclura* species. Despite the imperfections in the *Cyclura* database, it is still an exceptional tool in the management and understanding of these animals.

Dr. Bonnie Raphael processes medical samples at the headstart facility for the Grand Cayman iguana.
Photo by B. Raphael

Dr. Nancy Lung, Rick Hudson, and Richard Duffus do a health assessment on a free-ranging Jamaican iguana in the Hellshire Hills near Kingston.

Overview of health assessment findings

In general, the health of free-ranging *Cyclura* is excellent. Exceptions to this occur in populations of free-ranging iguanas that live in marginal habitat. This may be due to competition for food resources with domestic animals or loss of normal forage due to the introduction of non-native vegetation. In these cases body condition of the animals is less than ideal. Mucous membranes are pale and the animals just don't seem as robust as they should be for free ranging iguanas. Blood values will typically show chronic anemia with packed cell volumes of less than 25 %.

Another exception to the excellent health of free-ranging iguanas exists in the Mona Island iguana population, where problems with cataracts and other ophthalmic conditions occur in free-ranging adults. One theory for the high incidence of cataracts in this population is a normal age-related process in a population that is skewed to older animals due to predation of hatchlings. This theory makes sense, although similar population dynamics occur in other species of *Cyclura* and cataracts have not been identified in those aging populations. Nutritional, genetic and other factors must be considered.

Dr. Tim Reichard performs an ophthalmic exam on a free-ranging Mona iguana.
Photo by T. Reichard

Keratitis in an adult Mona iguana.
Photo by T. Reichard

For the headstart programs currently in place, the health of the animals is quite good. This is based on data gathered over years of health screens as described above. However, husbandry, health, and nutrition issues present constant challenges. Diligence is needed in all programs on a daily basis to ensure that animals are housed at an ideal density, matched in proper age and gender ratios, observed for signs of illness, and fed a fresh, balanced, and complete diet. Though these concepts seem straightforward, they can be difficult to ensure when headstart facilities exist in remote locations, independent of zoo or animal related institutions. It is important to maintain programs of annual health evaluations of animals in the facilities, including review of husbandry and nutrition practices. Relationships with range country veterinarians need to be maintained such that ill or injured headstart animals can receive timely medical care. The challenges are real. But the benefits of raising headstart animals in their range country, being exposed to the exact climate they will face in the wild, and being fed native vegetation that they will encounter in the wild are well worth the effort.

Establishment of normal blood values for *Cyclura* species

The collection of blood samples from headstart and free-ranging *Cyclura* has achieved two important goals. First, it has allowed veterinarians to evaluate the candidacy of an individual headstart animal for release (i.e., is the animal in good health prior to release). Second, data generated from blood count and chemistry analysis creates a database of normal blood values for these species of animals. Such a database provides a tool for evaluating the health of individuals and populations and it is used as a reference database during the medical management of iguanas in zoo and private collections

Appendix 6 lists the normal blood values for seven of the 14 taxa of *Cyclura*. The blood values listed include complete blood counts (evaluated for some species), plasma chemistry parameters for all species, and plasma vitamin D for 6 species. Note that health assessments continue to be an integral part of the *Cyclura* conservation programs. The database is continually expanded. Look for updated in future publications.

Blood work is an integral part of a pre-release screen for a head start iguana. Results of blood tests are compared to the normal values for that species. The best internal marker of overall health in the iguana seems to be packed cell volume. Iguanas in marginal health tend to show anemia before other changes are apparent. It is not uncommon to have an iguana with normal plasma chemistry, but have poor body condition and a packed cell volume of 25 % or lower. When anemia is present the animal should not be approved for release and further investigation into underlying health problems should be pursued. Blood results should be interpreted as in any clinical case, considering indicators for renal and liver status, occult infection, etc. Calcium, phosphorus, cholesterol and triglycerides should be interpreted in light of gender and reproductive status (see the section on reproduction).

Bacterial flora of the intestinal tract

Cloacal swabs for bacterial culture are part of the *Cyclura* health assessment program. Several years of data collection has resulted in an understanding of normal bacterial flora in the digestive tracts of several species of *Cyclura* (Jamaican, Anegada, Mona, Grand Cayman, and Ricord's iguanas.) In order to fairly compare bacterial flora across species, samples from each group of animals were processed at one laboratory using consistent methodology. Differences between species were identified, as well as differences from year to year within the same species. However, all groups showed a broad range of mixed bacterial flora of both gram positive and gram negative varieties. The most common isolates included:

Enterococcus spp
Escherichia coli
Bacillus
Enterobacter
Salmonella
Corynebacterium
Clostridium spp
Staphylococcus spp

Salmonella is considered to be a pathogenic bacteria in most animals. In reptiles *Salmonella* can cause infection as an opportunistic pathogen, but is usually found as part of the “normal” GI flora. Of 150 samples collected from captive and free-ranging healthy iguanas of 5 species, 51 salmonella isolates were made representing over 20 different species of salmonella. This gives an average positivity rate of 34 %. Across the populations of iguanas the positivity rate varied from 0 % to 100 % and often varied temporally within a species. In the health assessment of the Cuban iguana conducted by Alberts et al. (1998) no salmonella were isolated.

It is worth noting that *Pseudomonas aeruginosa*, a common pathogen in reptiles, was rarely identified in the normal intestinal flora of any of the 5 iguana species examined.

Parasites of free-ranging and headstart iguanas

Ticks and mites are commonly found on free-ranging *Cyclura*, sometimes in high numbers. The headstart iguanas tend to be cleaner than their wild counterparts, with only occasional ticks or mites identified.

Oxyurids, or pinworms, are a ubiquitous intestinal parasite in all species of *Cyclura* evaluated, particularly in free-ranging animals. Consumption of feces is common among young lizards, facilitating the transmission of intestinal parasites. Headstart iguanas are generally infected with oxyurids, though headstarted Cuban iguanas were free of intestinal parasites. Oxyurids are considered to be commensal, non-pathogenic nematodes. Coccidia are occasionally found in *Cyclura* fecals, including the Mona Island iguana and the Cuban iguana. Although coccidia have the potential to create illness in reptiles, this has not been a significant problems in *Cyclura* to date. More work needs to be done to identify the species of coccidia that invade the *Cyclura* intestinal tract and to evaluate its pathogenic potential.

Additional work also needs to be done to evaluate the prevalence and pathogenicity of hemoparasites in free-ranging *Cyclura*. Alberts et al. (1998) reported a high percentage of the erythrocytes of both headstart and free-ranging Cubans infected with the piroplasm *Sauroplasma*, most likely transmitted by arthropod vectors such as ticks or mosquitoes. Heavy hemogregarine infection can lead to anemia. However, light to moderate infections are usually not pathogenic in their natural hosts. It has been found in a number of *Cyclura* species in the Greater Antilles. Further work needs to be done to determine its range and clinical significance throughout the Caribbean.

Calcium/vitamin D

Normal circulating levels of 25-OH D_3 (25-hydroxycholecalciferol, the most active vitamin D metabolite in the iguana) are listed in Table 1. Health problems related to calcium and vitamin D are not commonly seen in free-ranging and headstart iguanas. This highlights one of the benefits of maintaining the headstart programs within the range countries, on diets that include native vegetation, in open-air enclosures that permit adequate access to natural sunlight. The one outlier in the vitamin D data set is the unusually high vitamin D levels in headstarted Anegada iguanas. The cause of this is still under consideration. It may be within a normal range for this species. If it is artificially high, it may relate to inadequate shade or excessive competition for shady spots within the headstart facility. In other headstart facilities it is important to keep trees and vegetation from over-growing the headstart enclosures to insure that animals have adequate access to prime basking spots.

Human-made causes of morbidity

Human-made factors do have a direct negative health effect on many free-ranging populations of *Cyclura*. These factors include predation by non-native predator species (e.g. domestic dogs and cats), habitat degradation, non-native vegetation out-competing dietary plants, competition for food resources with goats and cattle, vehicle-related injuries, and others. The prime factors impacting each *Cyclura* populations need to be evaluated and addressed on a species-by-species basis.

Pathology/Necropsy

The best way to increase our knowledge of pathologic processes affecting wild and captive *Cyclura* is to collect data through complete post-mortem evaluations. To date there is a limited database on the pathology of *Cyclura*, especially from the wild and headstart populations. As part of the normal course of events deaths do occur in free-ranging and headstart populations. Information on the disease processes that affect these populations is lost when pathologic data is not collected. Biologists and veterinarians working with *Cyclura* conservation programs are encouraged to train range country professionals in the importance of and techniques for thorough post-mortem examination. Permitting constraints make the importation of fixed tissues difficult but these hurdles can be overcome.

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Appendix

Appendix Table A: Possible diets using the suggested food category ranges (as fed basis) and their nutrient analysis (dry matter basis) compared to the target nutrient range.

Item	Units	As fed contribution to the diet					
		Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Target
Nutritionally complete feed[1]	%	35	35	35	35	100	35-100
Leafy greens	%	50	50	55	55	0	50-55
Vegetables	%	5	2.5	5	5	0	2.5-5
Fruits	%	2.5	2.5	5	0	0	0-5
Animal matter	%	2.5	0	0	2.5	0	0-2.5
Browse	%	5	10	0	2.5	0	0-10
Nutrient	Units	Nutrient analysis on a dry matter basis					
		Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Target[2]
Protein	%	15.7	14.9	14.9	15.9	14.0	12-26
Fat	%	3.5	3.2	3.1	3.5	3.0	3
Linoleic acid	%	1.8	1.6	1.8	1.8	2.0	1
Crude fiber	%	10.9		11.8	11.3	10.0	6-10
Acid detergent fiber	%	13.3	14.3	12.9	13.0	13.0	13-18
Calcium	%	1.1	1.2	1.0	1.0	1.0	0.6-1.0
Phosphorus	%	0.7	0.7	0.7	0.7	0.8	0.5-0.8
Potassium	%	1.2	1.2	1.4	1.0	0.5	0.5
Sodium	%	0.2	0.2	0.2	0.2	0.2	0.2
Magnesium	ppm	0.2	0.2	0.2	0.2	0.2	0.2
Iron	ppm	101.4	101.1	99.6	102.4	110.0	80
Copper	ppm	14.4	14.1	15.1	14.9	15.0	10
Manganese	ppm	54.5	54.1	56.1	91.1	60.0	50
Zinc	ppm	89.2	86.7	90.2	55.7	100.0	82
Iodine	ppm	0.8	0.8	0.8	0.8	1.0	0.6
Selenium	ppm	0.3	0.3	0.3	0.3	0.4	0.3
Vitamin A	IU/kg	58340	53230	66230	64060	7000	5000
Vitamin D_3	IU/kg	1844	1644	1754	1891	2100	-
Vitamin E	IU/kg	173.8	173.8	178.2	176.6	200.0	150
Vitamin K[4]	ppm	-	-	-	-	-	1
Vitamin C	ppm	835.9	798.4	954.4	900.3	200.0	200
Thiamin	ppm	9.1	8.7	9.5	9.4	10.0	8
Riboflavin	ppm	5.6	5.1	5.7	5.8	5.0	5
Pantothenic acid	ppm	18.9	18.0	19.8	19.5	20.0	15
Niacin	ppm	109.8	106.2	115.0	113.0	125.0	90
Vitamin B6	ppm	10.1	9.7	10.9	10.4	10.0	6
Folic Acid	ppm	1.8	1.8	2.1	2.0	1.0	0.8
Biotin	ppm	0.4	0.4	0.4	0.4	0.5	0.3
Vitamin B12	ppm	0.03	0.02	0.03	0.03	0.03	0.03
Choline	ppm	1276	1252	1356	1309	1500	1200

[1]The nutrient content of the nutritionally complete feed in the possible diets contains the minimums in Table 5. Many feeds exceed those minimums, resulting in adequate, but different, nutrient content of the complete diet.
[2]Suggested target nutrient ranges for growth and maintenance of iguanas on a dry matter basis.
[3]Currently no dietary level of vitamin D_3 has been shown to avoid vitamin D deficiency. Consequently, all iguanas should be provided with an adequate source of UV light in the range supporting the most effective biosynthesis of vitamin D at the 290-300 nm range.
[4]Database values for vitamin K were not available, thus a dietary level was not calculated.

Appendix Table B: The nutrient content of some currently available nutritionally complete feeds on a dry matter basis.

Nutrient	Units	Level in the diet					
		A[1]	B[2]	C[3]	D[4]	E[5]	F[6]
Metabolizable energy	Kcal/g	1.6	1.7	2.1	1.8	1.6	1.8
Protein	%	26.8	21.4	28.3	25.5	18.3	25.6
Fat	%	3.4	5.1	7.3	4.0	2.7	5.1
Linoleic acid	%	1.2	1.9		2.1	1.6	3.1
Crude fiber	%	17.8	9.9	10.5	9.2	9.1	12.2
Acid detergent fiber	%	23.9	13.5	15.8	12.4	13.1	18.9
Neutral detergent fiber	%	32.1	26.7	25.1	20.8	23.1	25.7
Ash	%	10.6	9.3	8.6	6.9	7.9	7.7
Calcium	%	2.8	1.3	1.1	1.2	1.5	2.1
Phosphorus	%	1.3	0.8	0.7	0.7	0.6	1.0
Potassium	%	1.9	0.6	0.7	0.4	0.4	1.3
Sodium	%	0.2	0.3	0.1	0.1	0.3	0.5
Magnesium	%	0.3	0.2	0.3	0.2	0.2	0.3
Iron	ppm	614.6	232.4	187.8	277.2	280.5	725.0
Copper	ppm	16.0	28.1	14.0	21.4	29.3	27.6
Manganese	ppm	131.5	233.6	83.1	56.5	84.3	166.7
Zinc	ppm	138.7	173.5	76.9	104.8	172.0	169.7
Iodine	ppm	1.7	1.1	-	1.1	1.4	1.9
Selenium	ppm	0.4	1.5	0.4	0.5	0.3	0.3
Vitamin A	IU/kg	22000	32900	-	8421	44000	7150
Vitamin D_3	IU/kg	9130	2200	-	1684	7260	1320
Vitamin E	IU/kg	220.0	220.0	-	210.5	72.6	363
Vitamin K	ppm	4.5	4.4	-	-	3.5	4.0
Vitamin C	ppm	308.0	242.0	-	210.5	550.0	-
Thiamin	ppm	15.4	8.3	-	5.3	9.8	12.1
Riboflavin	ppm	16.5	13.2	-	6.3	9.2	11.0
Pantothenic acid	ppm	56.1	53.9	-	21.1	66.0	35.2
Niacin	ppm	106.7	194.7	-	42.1	132.0	99.0
B_6	ppm	15.4	15.4	-	4.2	15.4	5.1
Biotin	ppm	0.5	0.6	-	0.2	0.11	0.6
Folic acid	ppm	10.2	7.7	-	0.5	8.7	1.9
B_{12}	Ug/kg	123.2	31.9	-	21.0	24.2	25.3
Choline	ppm	1837	3410	-	-	1320	1782

[1]Mazuri Iguana (linoleic acid, iodine and vitamins provided by the manufacturer, ME calculated, all other values chemically analyzed)
[2]Zeigler Iguana (linoleic acid, iodine and vitamins provided by the manufacturer, ME calculated, all other values chemically analyzed)
[3] ZooMed Juvenile Iguana (linoleic acid, iodine and vitamins provided by the manufacturer, ME calculated, all other values chemically analyzed)
[4]Marion Leafeater (linoleic acid, iodine and vitamins provided by the manufacturer, ME calculated, all other values chemically analyzed)
[5]Purina Monkey Diet Jumbo 5037 (linoleic acid, iodine, and vitamins provided by the manufacturer, ME calculated, all other values chemically analyzed)
[6]ADF16 (all values are approximate provided by the manufacturer)

Appendix Table C: Acid detergent fiber (ADF), neutral detergent fiber (NDF) fiber fractions of foods consumed by free ranging *Cyclura* spp. and commercially available produce on a dry matter (DM) basis.

Category	Food item	Unit	DM	ADF	NDF
Free ranging fruit[1]	Noni fruit	%	19.1	24.9	29.5
	Scaevola berry	%	10.9	12.8	13.5
	Nutmeg fruit	%	40.2	37.3	51.8
	Guana berry	%	26.6	20.0	20.2
Readily available fruit[2]	Apple	%	12.9	6.0	10.2
	Papaya	%	7.9	12.2	13.7
Readily available vegetables[2]	Carrot	%	11.8	8.9	9.7
	Broccoli	%	9.7	14.7	16.6
Free ranging leaves[1]	Morning glory	%	15.0	20.5	32.6
	Yellow root	%	23.5	38.6	43.4
	Wild sage	%	33.1	20.9	27.8
	Wild bamboo	%	61.6	30.5	54.3
Readily available leafy vegetables[2]	Turnip greens	%	8.9	17.5	20.1
	Romaine	%	6.7	14.1	16.3
Readily available browse[3]	Hibiscus leaves	%	19.1	14.3	42.7
	Mulberry leaves	%	42.6	17.4	20.3
	Bamboo leaves	%	52.0	39.2	69.4
Free ranging flowers[1]	Pea	%	12.0	18.8	27.1
	Pink cedar	%	13.9	29.5	34.4
	Queen of the night	%	18.6	21.0	31.2

[1]Fruits collected on Grand Cayman, Anegada, and Jamaica. A.M. Ward and J.L. Dempsey, 2005, 2006 unpublished data; A.M. Ward and J.L. Dempsey, 2003
[2]Schmidt et al. 1999.
[3]A.M. Ward, 2004, unpublished data.

Appendix Table D: A summary of nutrients consumed in zoological institutions and headstart facilities on a dry matter basis; means with standard deviation reflecting differences between institutions.[1]

Species		*C. collei*		*C. lewisi*		*C. pinguis*
State		Adult	Juvenile	Adult	Juvenile	Juvenile
Number of institutions		2	3	3	1	1
Number of animals		7	41	9	2	9
Body weight	kg	2.4±0.3	0.9±0.1	4.5±0.6	1.7	0.8
Dry matter intake	g/d/kg BW	4.5±0.7	15.5±9.4	4.1±1.8	7.6	22.9
Dry matter intake	% BW/d	0.5±0.1	1.6±0.9	0.4±0.2	0.8	2.3
Crude protein	g/d/kgBW	1.0±0.1	1.6±0.6	0.9±0.4	1.0	3.3
Acid detergent fiber	g/d/kgBW	0.9±0.2	1.6±1.1	0.9±0.6	2.9	4.9
Neutral detergent fiber	g/d/kgBW	1.0±0.3	1.8±1.1	1.1±0.6	3.2	5.1
Fat	g/d/kgBW	0.1±0.1	0.4±0.1	0.2±0.1	0.3	0.6
Ash	g/d/kgBW	na[2]	na	0.5±0.1	1.0	na
Crude protein	%	23.2±2.6	16.9±6.1	21.2±6.0	14.6	19.7
Acid detergent fiber	%	20.0±0.2	23.6±11.4	23.7±14.5	41.3	26.6
Neutral detergent fiber	%	22.1±3.4	28.9±14.5	26.7±11.5	42.6	27.3
Fat	%	2.8±0.7	3.6±0.8	5.3±1.1	4.3	3.2
Ash	%	na	na	13.3±6.0	12.2	na
Calcium	%	na	na	2.3±1.6	1.4	na
Phosphorus	%	na	na	0.5±0.3	0.1	na
Potassium	%	na	na	2.4±1.4	2.0	na
Sodium	%	na	na	1.0±0.8	2.0	na
Magnesium	%	na	na	0.5±0.3	1.1	na
Manganese	ppm	na	na	71.1±27.2	na	na
Zinc	ppm	na	na	58.1±54.2	na	na
Iron	ppm	na	na	na	na	na
Copper	ppm	na	na	11.3±7.9	na	na

[1]Ward et al. 2001, C. pinguis from Ward et al. 2003, C. lewisi from A.M. Ward and J.L. Dempsey, 2006, unpublished data
[2]Data not available.

Appendix Table F. List of plants consumed by free-ranging *Cyclura* spp.

	Plant Scientific name	Common name	Plant part consumed[1]
***Cyclura pinguis*[2]**			
	Acacia anegadensis	Pokemeboy	Fr
	Batis maritima	Saltwort	L
	Bourreria succulenta	Chink	Fr
	Byrsonima lucida	Gooseberry	Fr, L
	Capparis flexuosa	Limber caper	L
	Cassine xylocarpa	Wild nutmeg	Fr
	Coccoloba krugii	Crabwood	Fr
	Coccoloba uvifera	Sea Grape	Fr, L
	Conocarpus erectus	Buttonwood	Fr, L
	Cordia rupicola	Cordia	L
	Crossopetalum rhacoma	Poison cherry	Fr
	Croton discolor	Croton	L
	Dodonaea viscose	Dodonaea	L
	Eleodendron xylocarpum	Nutmeg	Fr
	Erithalis fruiticosa	Black candlewood	Fr, L
	Ernodea Littoralis	Guana berry	Fr, L
	Eugenia axillaries	White stopper	Fr
	Jacquinia arborea	Wash wood	Fr
	Lantana involucrate	Wild sage	L
	Melocactus intortus	Turk's cap cactus	Fr
	Pisonia subcordata	Loblolly	L
	Pithecellobium unguis-cati	Blackbead	L
	Portulaca oleracea	Pusley	L
	Rivina humilis	Wild tomato	Fr
	Rynosia uncinata	Darling plum	Fr
	Solanum racemosum	Canker berry	Fr, L
	Sporobolus virginicus	Seashore rush grass	Fr, L
	Strumphia maritime	Strumphia	Fr, L
	Stylosanthes hamata	Pencil flower	L
	Tabebuia heterophylla	Pink cedar	Fl
	Tetramirca canalicula	Wild orchid	Fl
	Tillandsia utriculata	Wild pine	Fl
	Ziziphis rignonii	Ziziphis	Fr
***Cyclura lewisi*[3]**			
	Asystasia gangetica	Ganges Rose	Fl, Fr, L, St
	Blutaparon vermiculare	Purselin, East end	Fl, Fr, L, St
	Chamaescyce mesembrianthemifolia	Titty molly, coarse	Fl, Fr, L, St
	Chamaescyce hypericifolia	Titty molly, fine	Fl, Fr, L, St
	Clitoria ternatea	Pea	L, Fr, Fl, V
	Hibiscus esculentus	Hibiscus	Fl
	Ipomoea pre-caprae	Morning Glory	Fl, L
	Morinda citrifolia	Noni	Fr
	Morinda royoc	Yellow root	L

	Portulaca oleracea	Purselin, soft	Fl, Fr, L, St
	Scaevola seriacea	Scaevola	Fr, L
	Sesuvium portulacastrum	Sea Purselin	Fl, Fr, L, St
	Stylosamthes hamata	Lucy Julia	Fl, Fr, L, St
	Tecoma stans	Tecoma	Fl
***Cyclura collei*[4]**			
	Bauhinia divaricata	Goat hoof	S
	Bunchosia media	Black cherry	Fr
	Capparis ferruginea	Stinking berry	L
	Comocladia velutina	Maiden plum	Fr
	Hibiscus tilaceus	Congomahoes	L
	Hylocereus triangularis	Queen of the night	Fl
	Lantana involucrate	White sage	L
	Lasiacis divaricata	Wild bamboo	L
	Metopium brownii	Hog doctor	Fr
	Morinda royoc	Strongback	Fr
	Opuntia spinosissima	Bine Pear	Fr
	Tabebuia riparia	Tabebuia	Fl
***Cyclura c. carinata*[5]**			
	Acacia acuifera	Rosewood	L
	Ambrosia hispida	None given	L
	Antirhea myrtifolia	None given	L
	Argythamnia argentea	Silverbush	L
	Bourreria ovata	Strong-back	L
	Bumelia Americana	Milkberry	Fl, L
	Casasia clusiaefolia	Seven year apple	Fr
	Coccothrinax inaguensis	None given	Fr
	Conocarpus erectus	Buttonwood	L
	Crossopetalum rhacoma	Poison cherry	Fr, L
	Croton linearis	Sassparilla	L
	Erithalis fruticosa	Black torch	Fr, L
	Ernodia var. littoralis	None given	L
	Euphorbia mesembrianthemifoliea	Seaside spurge	Stem tips
	Evolvulus squamosus	None given	L
	Guapira discolor	Pigeon berry	Fr, L
	Gundlachia corymbosa	Horse bush	L
	Ipomoea pescaprae	Beach morning glory	L
	Jacquinia keyensis	Joe-wood	Fl, L
	Manilkara bahamensis	Sapodilla	L
	Melocactus intortus	Turk’s cap cactus	Fr
	Opuntia stricta var Dillenii	Prickly pear cactus	Joints
	Passiflora pectinata	Passion flower	Fl
	Pithocellobium keyense	Black bead	L
	Phyllanthus epiphyllanthus	Sword-bush	Stem tips
	Pithecellobium unguis-cati	Cat’s claw	L
	Psidium longipes	Wild guava	L
	Rachicallis Americana	Wild thyme	Stem tips

	Randia aculeate f. mitis	Box briar	L
	Rhizophora mangle	Red mangrove	L
	Scaevola plumerieri	Inkberry	Fr, L
	Strumphia maritime	None given	Fr, Stem tips
	Zanthoxylum flavum	Satin-wood	L
	Ziziphus taylori	None given	L
***Cyclura r. rileyi*[6]**			
	Borrichia arborescens	Silver sea oxeye	Fl
	Rhachicallis americana	Wild thyme	Fl, L
	Opuntia stricta	Erect prickly pear	Pads

[1]Plant parts: flowers (Fl), fruit (Fr), leaves (L), stems (St), vine (V). Joints and stem tips as indicated.
[2]A.M. Ward and J.L. Dempsey, 2002, unpublished data, Gerber 2000, Mitchell 1999, Carey 1975, Grant 1937.
[3]A.M. Ward and J.L. Dempsey, 2005, unpublished data, Burton 2003.
[4]A.M. Ward and J.L. Dempsey, 2005, unpublished data.
[5]Lisi 2000 unpublished.
[6]Hayes et al. 2004.

Appendix Table G: Lizard TAG diet survey results of food items fed to *Cyclura* spp.[1]

Complete Feeds	Greens	Fruits	Vegetables	Browse	Animal	Supplements
Herbivore Biscuit	romaine	apple	carrot	sea grape	mealworms	Rep-cal
Mazuri Iguana Diet	parsley	grapes	yam	ackee	chicken	rep-cal minus D_3
Zoo Med Juvenile Iguana	collards	papaya	squash	hibiscus leaves	crickets	rep-cal w/D_3
Marion Leafeater	mustards	kiwi	green beans	hibiscus flowers	waxworms	Nekton rep
Rabbit Chow	turnip	strawberry	mung bean sprouts	oak branches	mice	D_3
	alfafla sprouts	blueberry	chick peas	bamboo		Nutrobal
	lime leaves	mango	frozen mixed	spineless cactus pads		cuttlefish
	Pseudoacacia	banana	peas	nasturtium flower		
	chicory	mix canned fruit	beans	west Indian shrubs		
	endive	raisins	pumpkin	iguana bamboo		
	waterICRs	raspberries	corn	*Laciacis divuracata*		
	dandelion			mulberry		
	spinach			red bud ssp.		
	kale			sunflowers		
	bok choy			daisies		
	Chinese mustard			purple cone flower		
	texas mustard			elm		
	chard					
	alfalfa					

[1]Responding institutions included: Ardastra Gardens, Central Florida Zoo, Durrell Wildlife Preservation Trust, Finca Cyclura, Fort Worth Zoo, Indianapolis Zoo, IRFC, Lincoln Park Zoo, Miami Children's Zoo, Miami Metro Zoo, Sedgewick County Zoo.

Appendix Table H: Biological Values

Parameter	*C. collei*	*C. pinguis*	*C. lewisi*	*C. ricordi*	*C. c. stejnegeri*	*C. r. rileyi*	*C. nubila* [3]	*C. cychlura nornata* [4]	Parameter
	Avg ± St dev/N	Avg ± St dev/N	Avg ± St dev/N	Avg ± St	Avg ± St	Avg ± St dev/N	Avg ± St dev/N	Avg ± St dev/N	
WBC (x1000/ml)			4.01 ± 2.53/32	6.56 ± 1.84/19			7.83 ±1.53/13	6.91±2.57/18	**WBC** (x1000/ml)
Heterophils %	57.2 ± 10.7/65	61.9 ± 15.7/62	58 ± 13/32	76.1/16	55.2 ± 24.7/19		49.46 ±6.81/13	4.25±1.84/18	**Heterophils %**
Lymphocytes %	8.1 ± 6.3/65	14.8 ± 10.6/62	16 ± 7/32	7.37/16	6.71 ± 3.7/19		35.15 ±7.67/13	1.28±0.68/18	**Lymphocytes %**
Azurophils %	24.6 ± 9.1/65	17.6 ± 9.1/62	14 ± 5/32	7.1/16	14.8 ± 5.1/19		9.62 ±1.37/13	0.04±0.06/18	**Azurophils %**
Eosinophils %	1.0 ± 1.9/65	2.8 ± 3.1/62	3 ± 2/32	16-May	5.9 ± 4.0/19		0.46 ±0.18/13	0.12±0.17/18	**Eosinophils %**
Basophils %	8.2 ± 5.2/65	1.6 ± 2.1/62	9 ± 7/32	2.1/16	4.0 ± 3.3/19		5.23 ±0.80/13	0.52±0.30/18	**Basophils %**
Monos %	0.8 ± 1.5/65	1.3 ± 2.7/62	0 ± 0/32	1.1 /16	0 ± 0/19		0.00 ±.00/13	0.24±0.19/18	**Monos %**
PCV %	38.15 ±5.27/75		32.7 ± 6.6/24	31.9/7		34.6 ± 4.2/18	29.12 ±0.74/13	29.06±3.70/37	**PCV %**
AST U/L	31.42	23.81 ±11.37/62	69.6 ± 79/47	39.7 ± 28/23	28.43±35.3/35	31.8 ± 22.3/21		29.47±16.38/37	**AST** U/L
CK U/L	1207 ±1380/85	2136 ±1887/62		2775 ±264/23	1536±2149/33	1085 ± 646/20	3738.5 ±504.3/16	2342±2572/37	**CK** U/L
Total Protein	7.24 ±1.29/100	6.19 ±1.17/62	7.2 ± 1.4/47		7.43±1.07/35	5.99 ± 1.0/21	6.7 ±0.4/16	4.80±0.88/37	**Total Protein**
Albumin gm/dl	3.20 ±0.42/95	2.69 ±0.33/62	2.8 ±0.4/47	2.13 ± 0.31/23	2.27±0.38/35	3.18 ± 0.64/21	2.6 ±0.1/16	2.03±0.38/37	**Albumin** gm/dl
Globulin gm/dl	4.15 ±1.10/90	3.50 ±0.95/62	4.5 ± 1.3/47	5.1 ± 0.89/23	5.16±0.84/35	2.81 ± 0.52/21		2.86±0.59/37	**Globulin** gm/dl
BUN mg/dl	0.44 ±1.1/50	0.18 ±0.49/45	1.1 ± 1.2/47	1.3 ± 0.82/23	1.20±1.11/35	0.29 ± 0.52/21	2.1 ±0.1/16		**BUN** mg/dl
Cholesterol	95.96 ±49.25/52	61.6 ±19.8/45	90.1 ± 40.4/47	55.43 ±	118.9±73.05/33	122.9 ± 53.4/21	82.1 ±9.6/16	96.81±33.71/37	**Cholesterol** mg/dl
Glucose mg/dl	201.1 ±33.3/101	215.6 ±63.6/62	195.7 ± 52.7/47	222.6 ± 49.8/23	175.2±57.2/35	173.9 ± 27.1/21	229.9 ±8.0/16	189.2±39.4/37	**Glucose** mg/dl
Calcium[2] mg/dl	11.59 ±2.40/99	11.64 ±2.66/60	17.0 ± 20.7/47	12.79 ± 2.07/23	13.23±3.5/31	12.3 ± 1.34/21	13.7 ±1.2/16	10.06±0.95/20	**Calcium**[2] mg/dl
Phosphorus	6.01 ±1.36/86	6.56 ±1.30/60	8.1 ± 2.7/47	5.55 ± 1.22/23	4.79±1.59/33	4.84 ± 1.82/21	5.8 ±0.3/16	4.72±1.42/20	**Phosphorus** mg/dl
Chloride mEq/L	113.9 ±12.6/90	127.7 ± 23.8/62	114.0 ± 5.5/47	102.4 ± 11.4/23	106.5±9.3/35	122.4 ± 9.2/21	125.3 ±2.1/16	118.5±7.4/37	**Chloride** mEq/L
Potassium	2.63 ±1.34/82	2.57 ± 1.45/62	3.0 ± 2.0/47	3.52 ± 1.27/23	2.83±0.94/35	2.18 ± 0.82/21	4.1 ±0.1/16	3.66±1.06/37	**Potassium** mEq/L
Sodium mEq/L	170.5 ±10.0/94	166.8 ± 6.1/62	175.5 ± 16.1/47	162.8 ± 14.8/23	161.88±8.95/35	176.29 ± 11.09/21	165.4 ±2.2/16	166.92±5.99/37	**Sodium** mEq/L
Uric Acid mg/dl	4.59 ±2.06/101	4.38 ± 1.78/62	4.8 ± 1.9/47	3.55 ± 2.05/23	3.10±1.46/35	2.58 ± 2.28/21	4.8 ±0.5/16	1.77±2.0/37	**Uric Acid** mg/dl
Triglyceride	144.4 ±154.2/76	120.5 ± 97.1/62	221.6 ± 222.5/47	69.8 ± 70.0/23	2.06.8±244.7/3	94.43 ± 126.98/21	159.8 ±40.5/16	103.5±75.45/20	**Triglyceride** mg/dl
Bile Acids	12.57 ±13.47/38	6.35 ± 3.9/45	6.8 ± 5.1/47	7.28 ± 7.03/23	6.61±6.66/35	26.21 ± 16.11/21		10.62±20.24/37	**Bile Acids**
Vitamin D	145±58/34 (HS)	319±95.6/61	272.8±134.8/29	222.4±113.0/22	142.4±64.26/10	162.8±57.4/17			**Vitamin D**
(25-OHD) ng/ml	157 ± 137/14	193.6±35.4/10	215 ± 78/2 (wild)			(wild)			(25-OHD) ng/ml