Iguana Times

THE JOURNAL OF THE INTERNATIONAL IGUANA SOCIETY
$6.00

VOLUME 4, NUMBER 2
JUNE 1995

Male San Salvador rock iguana, *Cyclura rileyi rileyi*, Bahamas. The reddish coloration is typical of individuals on Goulding Cay. *Photograph: William Hayes*

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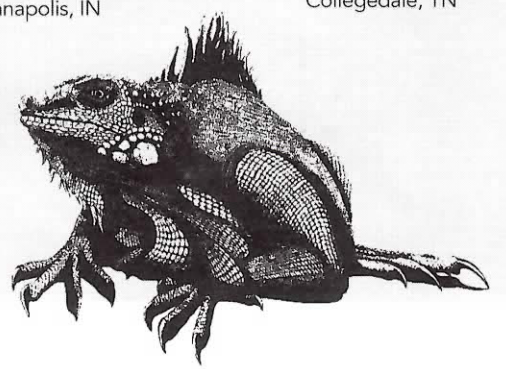

Journal of the International Iguana Society, Vol. 4, No. 2, pp. 21-30, 1995

RESEARCH ARTICLE

POPULATION STATUS AND CONSERVATION OF THE ENDANGERED SAN SALVADOR ROCK IGUANA, *CYCLURA R. RILEYI*

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ABSTRACT.—The San Salvador rock iguana, *Cyclura r. rileyi,* is a subspecies of one of three Bahamian iguana species, all of which are endangered. In May and July, 1994, we sampled six of the seven known populations confined to tiny offshore/inshore cays (sightings of iguanas on the San Salvador mainland are very rare). Lincoln-Peterson population estimates on two cays (based on resightings of marked iguanas) and censuses on other cays suggest a total population of 500-600 iguanas; however, numbers of juveniles are possibly underestimated. These data provide important baseline information by which future assessment of management needs can be made. We also identified threats to the long-term survival of several populations. The larvae of an introduced moth are infesting the prickly-pear cacti that are a major food source for iguanas on Green Cay; feral rats seen on Low Cay may prey upon iguana eggs and juveniles; and an unknown cause of mortality recently decimated the Guana Cay population. Continued research and direct intervention, for which we offer specific recommendations, are essential to preserve both the native habitat and genetic diversity of these imperiled populations.

Key Words: Bahamas, Reptilia, *Cyclura,* rock iguana, population size, conservation

Among the largest but least studied lizards in the world, Caribbean rock iguanas of the genus *Cyclura* are represented today by only eight species. On the islands where they occur, they are the largest native terrestrial herbivores. They are important grazers and seed dispersers (Auffenberg, 1982a; Iverson, 1985), assuming an integral role in maintaining the ecosystems in which they live. However, these draconian creatures are disappearing rapidly; up to six taxa are already extinct (Wiewandt, 1977). All eight surviving species are designated as endangered and afforded international protection by CITES (Convention on the International Trade of Endangered Species) Appendix I status. Their demise can be attributed directly to human activities. They are hunted for their meat in certain countries, smuggled illegally for the pet trade, and increasingly threatened by introduced plant and insect pests, feral animals, and rapid loss of habitat. As an alarming example of their vulnerability, feral dogs and cats brought by hotel construction workers led to nearly complete extirpation of a thriving iguana population (ca. 15,000) on Pine Cay, Caicos Islands, in less than five years (Iverson, 1978).

One of the most vulnerable of the three Bahamian species is *Cyclura rileyi,* considered the smallest of all rock iguanas. The three recognized subspecies are scattered on some of the most remote Bahamian islands. *Cyclura r. rileyi* (Figure 1) is confined to seven tiny offshore/inshore cays (islets) of San Salvador island; *C. r. nuchalis* exists on just two cays in the Acklins Bight; and *C. r. cristata* is restricted to a single cay in the southern Exumas (Blair, 1994).

For *C. r. rileyi,* a handful of population estimates have been published in recent decades. Auffenberg (1976) believed that populations were on the decline, none remained on the mainland of San Salvador itself, and that fewer than 200 individuals persisted on the satellite cays; in a later report (Auffenberg, 1982b), he considered the iguanas to be present on five cays and extirpated on five others. Based on transect surveys conducted on three cays (Manhead, Green, Low) in

Figure 1. San Salvador rock iguana, *Cyclura rileyi rileyi*, on Green Cay. *Photograph: Richard Moyroud*

1974, Gicca (1980) considered these populations to be near maximum densities and estimated a combined maximum of 93 animals. Assuming that iguana density on High Cay (where he saw only seven animals during his brief visit) was similar to other cays, he suggested another 113 iguanas were possible on High Cay and surmised that fewer than 500 animals remained on the mainland. Ostrander (1982) reported the discovery of a new population on Guana Cay in Hermitage Lake (Northeast Arm of Great Lake), where he saw or heard a minimum of 45 individuals and "conservatively" estimated the population to be at least 80. More recently, Blair (1991) visited several cays in 1990 and summarized their relative abundance on six cays, their very rare but continued presence on the mainland, and their presumed extirpation on at least seven cays. Blair believed that roughly 500 individuals remained. Although these reports reflected well the precarious nature of the iguana's status, none were based on rigorous sampling.

The purpose of this study was to evaluate the population status of *C. r. rileyi* on San Salvador Island, Bahamas, more precisely. In addition to our population estimates, we also report on several human-related factors that threaten the future survival of the subspecies.

Materials and Methods

STUDY SITE. San Salvador (Figure 2) is a relatively small island (156 km^2) situated east of the Grand Bahama Bank. Because it is not a part of any bank system, it has presumably been isolated from the rest of the Bahamian archipelago throughout its history (Olson et al., 1990). It is composed of limestone, with many karst features including caves, sinkholes and an abundance of fissures that serve as retreats for iguanas. The greatest elevation is 43 m (Smith, 1993). An extensive system of mostly hypersaline lakes comprises much of the surface area of the island. Temperatures average 31 °C during summer and 17 °C during the coolest month, December (Smith, 1993). Annual precipitation varies considerably, generally ranging from 100-180 cm, with a definite rainy (hurricane) season from August to November, and a lesser rainy season in May and June (Smith, 1993).

Centuries ago, the island was occupied by Lucayan Indians, whose impact on the native flora and fauna is poorly understood. In the pre-

vious century, however, the habitat of San Salvador was significantly altered when most of the island was under cultivation (Olson et al., 1990). Feral animals, in addition to habitat loss and probable hunting by humans, may have contributed to the iguanas' demise (cf. Iverson, 1978). Surviving colonies of iguanas, it would appear, are now largely confined to a handful of small cays just offshore and within the inland lakes (Blair, 1991; see Figure 2). During the last glacial period (which ended ca. 10,000 years ago according to Plummer, 1979), these cays would have been connected to the mainland (since water depths of only ca. 3-10 m now separate them) and were therefore probably populated by iguanas. But as sea levels increased, iguanas inhabiting the newly-formed cays became isolated. Some cays may have become populated or supplemented by iguanas that swam or "rafted" to them on floating vegetation from the mainland or other cays. Presumably, iguanas originally arrived at San Salvador via rafting (Schwartz and Carey, 1977).

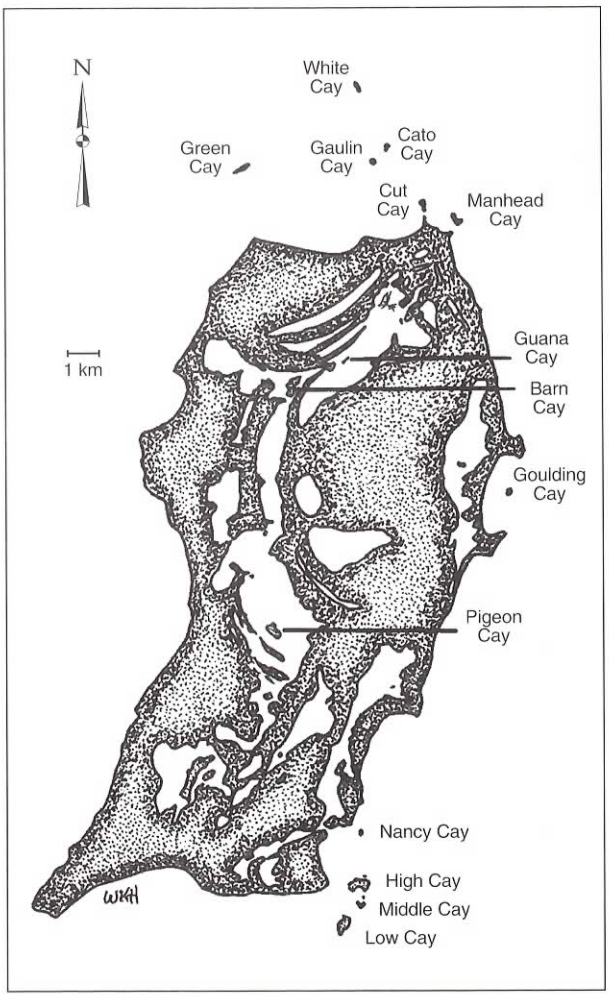


Figure 2. Map of San Salvador Island, Bahamas.

The vegetation of these cays is highly varied, particularly in plant diversity, which ranges from a mere 10 species on Green Cay to more than 40 species on Guana and High Cays (Moyroud and Ehrig, 1994). The vegetation on the offshore cays is similar in varying degrees to the coastal rock, the sand strand and sea oat, and the coastal coppice plant communities on the mainland (Smith, 1993). However, for cays within the inland lakes, the vegetation of Guana Cay resembles the blacklands (coppice) community on the mainland (Smith, 1993), while that of Pigeon Cay represents the mangrove community (Blair, 1991; Smith, 1993).

POPULATION SURVEYS. We began our studies in May 1993 by capturing and marking iguanas on three cays: Guana (n = 5), Manhead (n = 11), and Green (n = 12). In May 1994, we marked additional iguanas on Manhead (5 more) and Green Cays (35 more), as well as on Low Cay (n = 9); we visited but did not attempt to capture more lizards on Guana Cay. We also explored several cays lacking iguanas. Our marking technique was that of Rodda et al. (1988), consisting of two colored plastic (and later, glass) beads sutured to the nuchal crest by monofilament line.

We returned to San Salvador in July 1994 to conduct population surveys on five of the seven cays inhabited by iguanas. All censuses conducted in July were made during the heat of the day, between 1000-1500 hrs, in typically clear, dry weather. On some days, light showers occurred in the afternoons (stimulating iguana activity), but always after we had completed our surveys. During these censuses, iguanas on all cays were largely inactive due to the high midday temperatures. Most were located by two investigators carefully searching vegetation clumps in a coordinated manner so as not to double-count iguanas. While many were found at rest, numerous iguanas were detected only when flushed. Gentle probing of the denser brush with 2.7 m fishing rods was especially effective at flushing concealed, otherwise immobile animals.

We performed Lincoln-Peterson estimates of iguanas on Manhead and Green Cays, where there were sufficient marked animals (n = 16 and 47, respectively). This technique is used mostly for mark/recapture studies (Nichols, 1992), but the highly visible colored beads we used made resighting of marked and unmarked iguanas a better alternative to recapture. For the Lincoln-Peterson estimates, we recorded all iguanas seen or heard during a careful, deliberate search covering the entire cay. With the aid of binoculars, we categorized well-seen iguanas as either marked or unmarked. Poorly-seen iguanas were categorized as "uncertain" because we could not determine whether they were marked or not.

Accordingly, we had two estimators for iguana abundance: the numbers of well-seen and poorly-seen iguanas, respectively, observed during our cencuses. In both cases, because many iguanas were underground in burrows or were not flushed during the census, the numbers of iguanas counted represented only a portion of the iguanas on the cay. For well-seen iguanas, we calculated the total number of iguanas they represented (N_1) by use of the Lincoln-Peterson equation. In essence, the ratio of the numbers of marked ($N_{resighted}$) to total animals seen (N_{seen}) during a given census on a cay should be equal to the ratio of marked animals (N_{marked}, a known entity) to the total population represented by well-seen iguanas (N_1, an unknown number that is extrapolated). Hence, N_1 was estimated by the equation: $N_{marked}/N_1 = N_{resighted}/N_{seen}$.

The number of iguanas represented by poorly-seen individuals (N_2) had to be estimated in another way. To calculate these, the number of "uncertain" iguanas seen ($N_{uncertain}$) was multiplied by the ratio of marked animals (N_{marked}) on the cay to the number of marked animals resighted ($N_{resighted}$). The latter ratio represents the proportion of iguanas known to be present that were resighted during the census. Thus, $N_2 = (N_{uncertain})\,(N_{marked}/N_{resighted})$. Accordingly, the total population estimate (N_{total}) for a given cay was the sum of the estimate based on well-seen iguanas (N_1) and the estimate derived from poorly-seen, or "uncertain" iguanas (N_2).

Because of significant variation in body size among the populations (Goodge et al., 1995) and resultant confusion in clearly separating juveniles from adults on the different cays, and because several juveniles were marked in the Manhead and Green populations, we did not distinguish between size classes in our counts. Though widely employed by population biologists, the Lincoln-Peterson method has implicit assumptions that should always be specified. In our case, we assumed that: 1) the colored beads remained on all animals (we saw no evidence to the contrary, although several iguanas had lost the beads on one side of their neck); (2) mortality of marked animals was negligible [generally true of adult *Cyclura* (95-99% annual survival; Iverson, pers. comm.), and nearly all animals were marked adults]; (3) marked iguanas were as likely to be seen during the census as those never captured before [Iverson (1989) indicated that capture rates for *C. cychlura inornata* were similar for marked and unmarked iguanas]; and (4) the ratio of marked to unmarked animals was similar for animals seen poorly and those seen well enough to determine whether they were marked. Because juveniles were seldom seen, perhaps being less active at midday or occupying microhabitats that were not examined closely, we have possibly underestimated total population sizes.

On other cays without (or having too few) marked iguanas, we followed a similar, deliberate search that usually covered the entire cay, and simply counted the number of individuals encountered. On Low Cay, we concentrated our survey in the vicinity of sea grape (*Coccoloba uvifera*) stands (the favored habitat of iguanas on this cay) along the western and northern portions of the island. The large stand on the west side of the cay was so extensive, however, that we chose not to tramp through it in search of additional iguanas. Similarly, our census was limited on Goulding Cay (to about two-thirds of the habitat) by the nearly impenetrable density of much of the vegetation.

Simply counting iguanas on these cays, however, is not enough to establish the population size. The Lincoln-Peterson surveys indicated that approximately one-third of the marked iguanas on Manhead (6/16; 37.5%) and Green (15/47; 31.9%)

cays were resighted (21/63 for both cays combined; 33.3%). This ratio suggests that, on any given cay (under similar survey conditions), only one-third of the population present is likely to be encountered during a census. Hence, for the other cays visited, we simply multiplied the number of iguanas seen by three to derive a reasonable estimate of population size (our "observed × 3" method). Obviously, this multiplication factor might vary for season, weather conditions, and time of day. Therefore, one cannot directly apply our method to surveys at other times of the year, or to other populations. The investigator must have some means of first estimating the percentage of animals that can be counted during the brief time when a census is taken. In our case, the two Lincoln-Peterson estimates provided a statistically justifiable basis for the method.

Figure 3. The extensive prickly-pear cacti (*Opuntia stricta*) on Green Cay (left) are being decimated by the larvae (inset; a video image) of an introduced moth from South America (*Cactoblastis cactorum*). *Photographs: William Hayes*

Results

The absolute numbers of iguanas found on each cay, and their corresponding population estimates, are summarized in Table 1. Prior status of the iguanas, based on reports by previous investigators, is also summarized.

On Manhead Cay, twenty animals were seen well enough to determine whether they were marked; of these, six were previously marked. The Lincoln-Peterson index suggested a total of 53 for well-seen iguanas. Six (37.5%) of the 16 marked animals were resighted. An additional eight iguanas were poorly seen, and these "uncertain" sightings were estimated to account for another 21 animals. By summing these two estimates, we calculated a total of 74 iguanas on Manhead Cay, with an absolute minimum (actual number of iguanas counted) of 28 (see Table 1).

Similarly, on Green Cay we sighted 61 iguanas well enough to determine if they were marked, and 15 had been marked previously. The Lincoln-Peterson index suggested a total of 191 iguanas based on the well-seen sightings. Fifteen (31.9%) of the 47 marked animals were relocated. Another 19 animals were poorly seen, and these were estimated to account for an additional 60 iguanas. Summing the two estimates, we calculated a total of 251 iguanas on this cay, with an absolute minimum of 79 animals (Table 1).

The absolute minimum number of San Salvador iguanas is 174, while the estimated population size (excluding the unknown numbers on Pigeon Cay) is 527 (Table 1). Green Cay probably hosts the largest population, while two cays (Gaulin and Guana) may have fewer than 25 individuals.

Several potential threats to iguana well-being were documented. On Green Cay, we discovered that many stands of prickly-pear cacti *(Opuntia stricta)* were infested with the larvae of *Cactoblastis cactorum* moths (Figure 3). On Manhead Cay, we observed many iguanas having a tar-like substance adhering to their snouts. In 1993, eight of the nine iguanas photographed (89%) were thus affected, whereas two of eight (25%) had the condition in May and August 1994. However, this

Table 1. Summary of previously published status and our recent (1994) population estimates of iguana (*Cyclura r. rileyi*) populations on San Salvador Island, Bahamas.

Known/Potential Populations (area)	Prior Status	Absolute Minimum	Estimated Pop'n Size	Census Method
Barn Cay (14 ha)	Extirpated[a]	0	0	Observed × 3
Cato Cay (3 ha)	Extirpated[b,c]	—	—	Not visited
Cut Cay (3 ha)	Extirpated[b,c]	0	0	Observed × 3
Gaulin Cay (2 ha)	Extirpated[b,c,d]	3	9	Observed × 3
Goulding Cay (3 ha)	Small pop'n[a]	30	90	Observed × 3
Green Cay (5 ha)	Small pop'n[a,c,d]	79	252	Lincoln-Peterson
Guana Cay (1 ha)	Abundant[e]	8	24	Observed × 3
High Cay (15 ha)	Extirpated[a,b,d]	0	0	Observed × 3
Low Cay (12 ha)	Abundant[a,c,d]	25	75	Observed × 3
Mainland (15,000 ha)	Small pop'n[b,c]	1	3	Observed × 3
Manhead Cay (3 ha)	Small pop'n[a,d]	28	74	Lincoln-Peterson
Middle Cay (2 ha)	Extirpated[a]	0	0	Observed × 3
Nancy Cay (1 ha)	Unreported	0	0	Observed × 3
Pigeon Cay (10 ha)	Small pop'n[c]	—	unknown	Not visited
White Cay (3 ha)	Extirpated[a,b,d]	—	—	Not visited
Estimated Totals		**174**	**527**	

Population surveys conducted in May (Barn, Guana, Middle Cays) or July (all other keys we visited) of 1994; for comparative purposes only, sizes of cays (area in ha) are crude estimates, based on a map lacking accurate surface detail, and are rounded to nearest hectare; absolute minimum = number of animals seen; see text for explanation of census techniques.

[a] Auffenberg (1982b), based on relative numbers observed and interviews with local residents; he estimated the Low Cay population in excess of 100.

[b] Don Gerace (pers. comm.) reported that although iguanas have long been absent from Cato, Cut and White Cays, they were still present on Gaulin (up to 18) and High Cays in the early 1980's; further, a small mainland population (2+ iguanas) still persists near Fortune Hill. The mainland iguana we observed was a juvenile several hundred meters west of Sandy Hook.

[c] Blair (1991) updated Auffenberg's (1982b) summary based on relative numbers observed; he saw only 5 iguanas on Pigeon Cay and none on Gaulin Cay in 1991; however, Sandra Buckner (pers. comm.) saw one individual on Gaulin Cay in 1993.

[d] Gicca (1980) saw 27 iguanas on Green, 15 on Manhead, 10 on Low, and 7 on High Cay in December, 1974; by transect methods, he estimated 35, 28, and 30 iguanas on Green, Manhead and Low cays, respectively. He saw no iguanas on White and Gaulin cays.

[e] Ostrander (1982) saw and heard approximately 45 iguanas, and estimated at least 80 present on Guana Cay.

condition may reflect natural foods that they had eaten (e.g., fruits or insect larvae; T. A. Wiewandt and J. B. Iverson, pers. comm.). On Guana Cay, we sighted 15 iguanas in May 1993, while in May 1994 we sighted only eight or nine (including two juveniles). Six adult carcasses (including an individual marked in 1993), all in a similar state of decay, were discovered on Guana Cay in March 1994, and two others in a much greater state of decay were found in May 1994 (Jones et al., 1995; see Figure 4). Lastly, on Low Cay, three adult rats (of unknown species but non-native to San Salvador; Olson et al., 1990) were seen during midday on 20 July 1994, all within or at the periphery of dense *Coccoloba* patches. Local residents described an abundance of rats on the mainland.

Figure 4. Mummified iguana from Green Cay. Decaying iguana carcasses found on Guana Cay in 1994 were indicative of a die-off of unknown cause. *Photograph: William Hayes*

Discussion

Presently, *C. r. rileyi* appears to be limited to seven small populations on offshore/inshore cays and one or more small populations on the mainland. However, further exploration, particularly on the mainland and on the southernmost hypersaline lakes, may reveal additional colonies.

It is interesting to compare our data with the conclusions ("prior status" in Table 1) arrived at by other investigators. For example, the "small population" on Green Cay is much healthier than previously believed; indeed, it may host nearly half of all San Salvador iguanas. Likewise, the "small" populations on Manhead and Goulding Cays appear to be comparable in size to the "abundant" population on Low Cay. The population on Goulding Cay, which appears to be flourishing, evidently had not been visited in at least 14 years (Auffenberg, 1982b). Compared to Auffenberg's (1982) dismal estimate of 200 remaining iguanas and Gicca's (1980) low estimates for the three cays he sampled, our estimation of 500-600 iguanas is closer to that predicted by Blair (1991). If we underestimated the comparatively secretive juvenile population (which we suspect), total numbers may be even higher. Nevertheless, these numbers still rank the subspecies among the rarest lizards in the world, and the remaining populations are critically threatened (see below). Our results serve as important baseline data for future assessment of *C. r. rileyi.*

Consistent with previous reports, we failed to locate iguanas on Barn, Cut, High, and Middle Cays. To these we can add that iguanas are not present (and likely never were, considering the minimal vegetation) on tiny Nancy Cay, directly north of High Cay. More importantly, we discovered three adult iguanas on Gaulin Cay, where they were suspected of being extirpated (Blair, 1991). Evidently, a small population still coexists with the several hundred pairs of brown noddies (*Anous stolidus*) and sooty terns (*Sterna fuscata*) that nest there. The Gaulin population probably never has been sizeable, and therefore genetic sampling of the iguanas should be a high priority.

Extirpation of iguanas on several of the cays has apparently been quite recent. Auffenberg (1982b) spoke with local residents who indicated that iguanas were present on Barn Cay in the early 1970's, but neither he nor our group could find iguanas or any sign of their presence. Gicca (1980) encountered iguanas on High Cay as recent as 1974, but they were evidently gone by 1980 (Auffenberg, 1982b). High Cay, however, is large and vegetationally diverse enough to con-

ceal a small remnant of iguanas, but searches in March 1994 by Jones et al. (pers. comm.) and by us in May and July found none.

Unfortunately, most of the surviving populations are presently vulnerable to human-related causes. The prickly-pear cacti on Green Cay, a major food source and one of only 10 plant species on the island (thus providing a very low diversity diet; cf. Auffenberg, 1982a), are under severe attack by the larvae of a moth *(Cactoblastis cactorum)* introduced to the Caribbean from South America several decades ago (Ehrig, pers. comm.). To date, no effective means of controlling the moth are known, and as a result the cacti population may decline dramatically. The relationship between cactus destruction and iguana abundance and condition should be closely monitored, and cacti on other cays should be inspected periodically for infestation.

Iguanas on Guana Cay experienced a mysterious die-off in the spring of 1994, as evidenced by the discovery of eight adult carcasses that appeared to be several weeks or more in decay (Jones et al., 1995). Because the carcasses all appeared to be in similar states of decay, they may have died within a narrow time frame of a similar, but unknown, cause. Ostrander's (1982) observation of 45 individuals contrasts sharply with the maximum of 15 individuals seen by us in May 1993, and of 8-9 individuals seen by Jones et al. (1995) in March and in May 1994. This population is parasitized by ticks, which have not been detected on other cays visited (Goodge et al., 1995). Perhaps the added stress of parasitism (e.g., reduced blood cell volume, especially in the case of adult lizards; Dunlop and Mathies, 1993) made the iguanas more susceptible to the agent that caused their deaths. However, the live iguanas seen in March (C. Jones, pers. comm.) and in May appeared to be perfectly healthy, with no obvious weight loss. Several juveniles were among the sightings; hence, some successful reproduction is occurring. Occasional blood screening (cf. Auffenberg, 1982b) could help identify causes of mortality.

With continued downsizing of the Guana Cay and other populations, inbreeding depression and random extinction events become increasingly likely. Moreover, a minimum level of social interactions may also be necessary to stimulate maximal reproductive output. Although introduced populations of *Cyclura* have become established with as few as three founders (Ehrig, pers. comm.), such success may be an exception more so than the rule.

On Low Cay, juvenile and subadult iguanas appear to be virtually absent. In contrast, in March of 1982, Auffenberg (1982b) reported seeing numerous juvenile iguanas on the cay. Because we saw numerous juveniles on both Manhead and Green Cays, we doubt that the different seasons of sampling (March vs. May and July, respectively) were responsible for the discrepancy between 1982 and 1994. The presence of rats and conspicuous lack of small iguanas (only one juvenile seen during the May 1994 expedition) suggests that the introduced rats are harming the population, most likely by preying upon juveniles and/or eggs. Most iguanas that we saw appeared to be old adults (Figure 5) holding territories along the periphery of the enormous *Coccoloba* stand on the west side of Low Cay, but it is possible that the smaller iguanas were more concentrated in the center of the stand (where we did not search) or in another microhabitat we overlooked. Iguanas have already become extirpated on nearby High Cay, where evidence of rats led Auffenberg (1982b) to suggest them as the cause of the iguanas' demise. The potential predation by rats upon iguanas should be evaluated both by direct observation (if possible) and by experimentation. Further, the cay is small enough that the rats could probably be extirpated by live-trapping at night, when iguanas are inactive.

Some of the cays presently inhabited by iguanas, Green Cay in particular, are probably close to their carrying capacity. With the exception of Low Cay (and possibly High Cay), feral animals do not appear to threaten populations. This is in contrast to the mainland, where feral animals would negate reintroduction into any but the most remote localities. Other cays, however, clearly are not at their carrying capacity—most notably Guana Cay and the cays where populations have been extirpated. The latter cays need to be carefully examined for possible reasons why iguanas

Figure 5. The iguanas on Low Cay appear to be mostly old adults. Although regarded as the smallest *Cyclura* species, *C. r. rileyi* on Low Cay attain a maximum body size equivalent to or larger than several other taxa. *Photograph: William Hayes*

disappeared. Because local extinction events can occur (e.g., by natural course of disease), we need not assume that empty cays are incompatible with iguanas. If these cays can be deemed or rendered satisfactory, iguanas from healthy populations or from a head-start/release program (e.g., Alberts, 1995) could be reintroduced.

However, reintroductions of iguanas cannot be done haphazardly. It is important that we first ascertain the genetic composition of each and every population so that we can work to maintain genetic diversity—and if necessary the genetic identity—of the populations. Because of their isolation, presumably with reduced gene flow, individual populations may have diverged genetically. Accordingly, management decisions should be based on genetic information. For example, populations low in number could be most rapidly replenished by translocation of individuals from other populations—but only if the iguanas are deemed genetically compatible. Currently, we are comparing DNA samples from each population to make better-informed management decisions in the future.

In addition to the factors discussed already, we must consider direct human effects. Although the local residents occasionally collect bird eggs from the cays (K. Gerace, pers. comm.), they evidently do not feed on iguanas, and most islanders express respect and concern for their well-being. Smuggling, however, has been a problem (D. Gerace, pers. comm.). Increased visitation of the cays spawned by the growing tourism industry represents another threat. These problems could be at least partially alleviated by a public relations campaign that should include posting information signs on each cay (as done recently in the Allan's Cays; see Iguana Times 1(5):13) and distributing pamphlets that alert residents to report smugglers. Fortunately, San Salvadoran officials have expressed a commitment to safeguarding their endemic iguanas, and (like many residents) are alert to any boaters that visit cays harboring iguanas.

Clearly, the San Salvador rock iguana and other endangered *Cyclura* species will continue to decline without direct intervention. As primary agents of their demise, we must take seriously our responsibility for the stewardship of these unique relics of West Indian natural history.

Acknowledgements

We are indebted to numerous individuals for their generous and enthusiastic assistance with this project. The following participated in the capture and processing of iguanas: S. and S. DeLay; R. W. Ehrig; A. and F. Ferko; B., D. and J. Francis; N. Gonzalez; T. Haack; E. Harris; M. Hills; R. Moyroud; D. Sammer; T. Simoes; and Dr. Jerry Carpenter with his students from Northern Kentucky University. C. Jones, C. and M. Keith and G. Livingston visited Guana and Barn Cays during the May expedition. R. Armentrout helped conduct the survey on Green Cay, and J. Garbisch assisted with the census on Goulding Cay. R. W. Ehrig not only discovered and identified the *Cactoblastis* larvae, he freely offered suggestions and advice based on his extensive knowledge of *Cyclura* biology. S. Buckner and D. Gerace kind-

ly supplied valuable information and heartfelt encouragement. J. Iverson, T. Wiewandt and two anonymous reviewers offered suggestions that improved the manuscript. Research was supported by the Bahamian Field Station and by grants to WKH from Southern College and from the Geoscience Research Institute (Loma Linda University, California).

Literature Cited

Alberts, A. 1995. A reintroduction program for the iguanas of Guantanamo. Iguana Times 3(4):10-12.

Auffenberg, W. 1976. Bahama Rock Iguanas, Part Two. Bahamas Nat., Summer 1976:9-16.

Auffenberg, W. 1982a. Feeding strategy of the Caicos ground iguana, *Cyclura carinata*. Pp. 84-116 in: Burghardt, G. M. and A. S. Rand (Eds.), Iguanas of the World: Their Behavior, Ecology and Conservation. Noyes Publ., Park Ridge, New Jersey.

Auffenberg, W. 1982b. Conservation of Bahamian Rock Iguanas (*Cyclura* sp.). Unpublished Project Report, U. S. Fish & Wildlife Service.

Blair, D. 1991. Update on the status of the San Salvador rock iguana, *Cyclura rileyi rileyi*. Iguana Times 1(2):1-3.

Blair, D. 1994. Rock iguanas. Reptiles 1(4):40-63.

Dunlap, K. D. and T. Mathies. 1993. Effects of nymphal ticks and their interaction with malaria on the physiology of male fence lizards. Copeia 1993:1045-1048.

Gicca, D. 1980. The status and distribution of *Cyclura r. rileyi* (Reptilia:Iguanidae): A Bahamian rock iguana. Carib. J. Sci. 16:9-12.

Goodge, B., D. Brouhard, W. K. Hayes, D. M. Hayes and R. L. Carter. 1995. Population estimates, morphological variation, and conservation of the San Salvador Island rock iguana, *Cyclura r. rileyi*. J. Tenn. Acad. Sci. (abstract in press).

Iverson, J. B. 1978. The impact of feral cats and dogs on a population of the West Indian rock iguana, *Cyclura carinata*. Biol. Conserv. 24:3-73.

Iverson, J. B. 1985. Lizards as seed dispersers? J. Herpetol. 19:292-293.

Iverson, J. B. 1989. Natural growth in the Bahamian iguana *Cyclura cychlura*. Copeia 1989:502-505.

Jones, C., G. Livingston and C. Keith. 1995. Mortality and ecological observations on rock iguanas (*Cyclura r. rileyi*) of Guana Key, San Salvador Island, Bahamas. J. Tenn. Acad. Sci. (abstract in press).

Moyroud, R. and R. W. Ehrig. 1994. I.I.S. vegetation studies. Iguana Times 3(2):13-16.

Nichols, J. D. 1992. Capture-recapture models. BioScience 42:94-102.

Olson, S. L., G. K. Pregill and W. B. Hilgartner. 1990. Studies on Fossil and Extant Vertebrates from San Salvador (Watling's) Island, Bahamas. Smithson. Contrib. Zool. 508:1-15. Smithsonian Inst. Press., Washington, D. C.

Ostrander, G. K. 1982. Discovery of an isolated colony of rock iguanas. Bahamas Nat. 6(2):22-24.

Plummer, C. C. 1979. Physical Geology. Wm. C. Brown Co. Publ., Dubuque, Iowa.

Rodda, G. H., B. C. Bock, G. M. Burghardt and A. S. Rand. 1988. Techniques for identifying individual lizards at a distance reveal influences of handling. Copeia 1988:905-913.

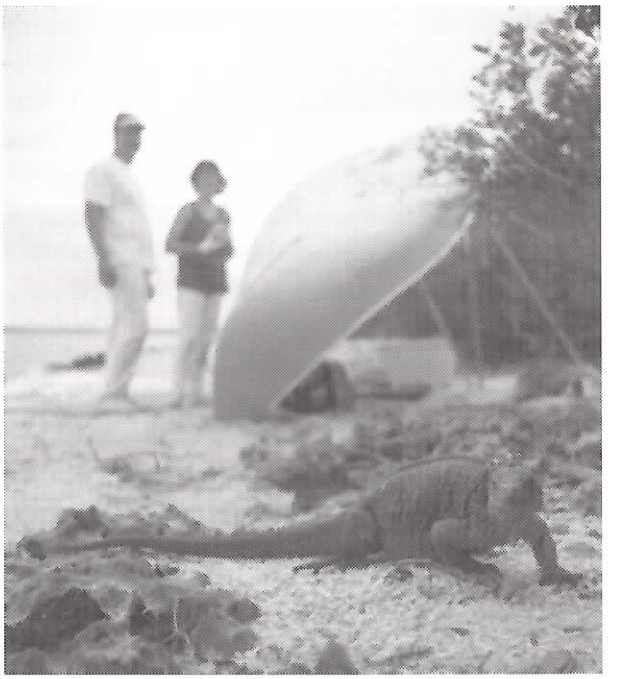
Schwartz, A. and W. M. Carey. 1977. Systematics and evolution in the West Indian iguanid genus *Cyclura*. Stud. Fauna Curacao and Carib. Is. 53(173):15-97.

Smith, R. R. 1993. Field Guide to the Vegetation of San Salvador Island, the Bahamas. 2nd Edition. Bahamian Field Station, San Salvador, Bahamas.

Wiewandt, T. A. 1977. Ecology, behavior, and management of the Mona Island ground iguana, *Cyclura stejnegeri*. Unpubl. Ph.D. dissertation, Cornell University, Ithaca, New York.

Acting Editor: John B. Iverson
Received: 3 February 1995
Accepted: 2 March 1995

NOTE ADDED IN PRESS: We visited Pigeon Cay in March 1995 and saw or heard 15 iguanas—all at the periphery of the cay. We assume iguanas also inhabit the virtually impenetrable mangrove interior, in which case a healthy population would be present. Regarding the rats on Low Cay, a recent article (by A. Cree, C. H. Daugherty and J. M. Hay, 1995, Conservation Biology 9:373-383) provides evidence that island populations of the tuatara (*Sphenodon punctatus*), an iguana-sized reptile in New Zealand, have been significantly impacted by introduced rats. Thus, we are further convinced that rats pose a serious risk to the future of the Low Cay iguanas.



This marked female on Guana Cay appeared to be copulated by a male within one hour of being processed and released on 26 May, 1993.
Photograph: William Hayes

CHUCKWALLAS

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316 W. MISSION #117, ESCONDIDO, CA 92025

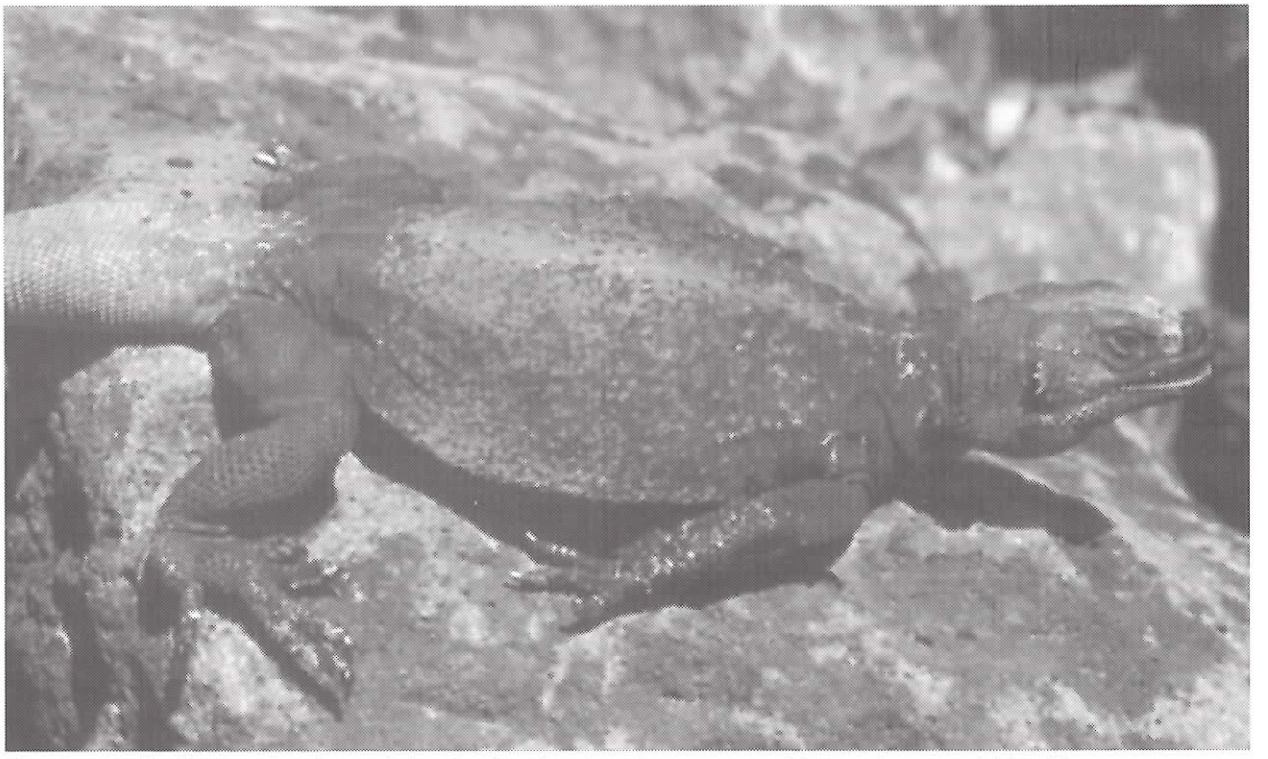
It is not uncommon while driving or walking the back roads of the American southwest to catch a glimpse of a large, dark saurian shape perched high atop a rocky outcropping or ancient crumbling lava flow. I have often attempted to approach these creatures only to have them quickly slip into one of the deep fissures or dark crevices within their rocky domain.

If you are well prepared and have thought to bring along a high-powered flashlight—the most unlikely of tools for observing diurnal lizards—you may be rewarded with the sight of the United States' largest nonvenomous lizard, the chuckwalla (*Sauromalus obesus*). By shining your light into the dark recesses of the proper crevice, you will see the chuckwalla wedged tightly inside. "Chucks" have a rough granular skin and, once inside a crevice, they can gulp air, increasing their volume by up to 53 percent, and wedge themselves tightly against the sides of their rocky retreat. Thus inflated, they are almost impossible to remove without damage to the lizard or rocky outcropping.

Description

The name "chuckwalla" (sometimes spelled "chuckawalla") is a corruption of the Mexican/Spanish name for this lizard, "chacahuala." These large lizards are second only in size in the United States to the venomous gila monster, and they reach snout-to-vent lengths of nearly 20 cm (8 inches) and overall lengths of over 38 cm (15 inches). They are heavy-bodied, robust and flattened dorsoventrally. In fact, their scientific name, *Sauromalus obesus,* means literally "fat, flat lizard."

Chuckwallas are characterized by loose folds



The chuckwalla, *Sauromalus obesus,* is locally abundant in rocky outcrops of the southwestern United States. *Photograph: Thomas A. Wiewandt.*

of skin on the neck and sides and a broad-based tail with a blunt tip. Male *S. obesus* have one or two rows of femoral pores and are generally very dark bodied with rusty red or orange sides and a buff to yellow tail. Females are normally lighter in color and often retain the dark banding pattern across the body and tail that is also characteristic of juveniles.

These saxicolous (rock dwelling) lizards inhabit nearly every lava flow and rocky hillside from the desert side of the mountains of Southern California east to central Arizona, and southward from the extreme southern portions of Nevada and Utah into northwestern Mexico in western Sonora. The creosote bush occurs throughout most of the chuckwalla's range, which also closely parallels that of its relative, the desert iguana, *Dipsosaurus dorsalis.* The desert iguana requires a different habitat, however, preferring open, flat regions and sandy washes.

Chuckwallas are members of the family Iguanidae, a group characterized by large size and the fact, rare among lizards, that they are all chiefly herbivores as adults.

Diet

"Chucks" prefer the shoots and flowers of desert annuals that appear following spring rains. Only after all the annuals die in May do they shift their diet to perennials such as sweet bushes (*Bebbia juncea*). More than 22 different species of plants have been identified as being consumed by wild chuckwallas: saguaro (fruit); palo verde, mesquite, and acacia (leaves, flowers, and beans); brittle brush (leaves and flowers); wolfberry; ironwood (leaves); creosote (flowers) and others.

Predators

Chuckwallas have numerous natural enemies in the wild, particularly when they are small. Rats are potential predators of both eggs and young, and several species of snakes are large enough to feed upon adult chucks, although that is probably rare.

In the southern part of their range, the young of some species of *Sauromalus* are eaten by the Mexican spiny-tailed iguanas (genus *Ctenosaura*). Coyotes and kit foxes take a fair number of individuals, as evidenced by the numerous remains of chuckwallas found in their droppings. Basking chucks seem very alert to anything flying overhead, including both birds and airplanes; they will often immediately dash to cover when one approaches. Some of their avian predators are believed to be red-tailed hawks, falcons, ospreys and ravens. Unfortunately, as man encroaches more and more into the chuckwalla's habitat, domestic or feral dogs and cats kill increasing numbers of these lizards each year.

Reproduction

The more northern forms of chuckwallas hibernate during the winter months, emerging in the spring when they begin their reproductive activities. Female *S. obesus* do not nest every year, producing only about one clutch of eggs every two years on average. In fact, in dry years when food resources are scarce, they may not breed at all. Even in boom years of heavier than normal rainfall and increased plant growth, only about one-third of the sexually mature females will lay eggs.

Dominant mature males establish territories averaging 0.57 ha during years of favorable conditions in order to secure mating rights with females. The females' territories are substantially smaller, averaging 0.17 ha, and several females will often be found within one male's territory. Late mornings and afternoons will often find groups of chuckwallas (but never more than one adult male) basking together on raised areas of rock and flat boulders. Size seems to be the dominant factor for males establishing territories. These territories are actively defended against other mature males, but not against females or juveniles.

By late March, the males begin to show increased interest in the females within their territories, and they begin to initiate the courtship and mating process. Intromission lasts a surprisingly long time in comparison with other iguanas, and in at least one species, *S. varius,* may occur for up to one hour! Mating activity continues throughout April and May, and by June or July the females begin to select nest sites. Nest burrows are dug by the gravid female to a depth equal to

The San Esteban chuckwalla, *Sauromalus varius,* lives on small islands in the gulf of California, and may exceed 12" snout-vent length. Large body sizes are typical of iguanas that live on islands. *Photograph: Thomas A. Wiewandt.*

about her total overall length. An enlarged terminal chamber is constructed into which the female deposits 12 to 14 eggs, averaging 20 mm long by 15 mm wide, and weighing about 8 g each.

Before refilling the nest burrow with soil, the female soaks the ground with a viscous cloacal fluid that apparently helps to keep humidity within the nest chamber at a proper level. Eggs usually hatch in September after approximately 12 weeks of incubation. Juvenile *S. obesus* grow at the average rate of 0.14 g per day for males and 0.06 g per day for females.

Taxonomic Forms

Currently, there are 11 taxa recognized within the genus *Sauromalus.* Many of these are insular forms restricted to roughly 22 islands in the Gulf of California. Most of these island forms are very similar in size and structure to *S. obesus,* but others, like *S. varius* and *S. hispidus,* reach truly "gigantic" proportions! In contrast to *S. obesus,* which attains weights of up to 385 g (0.85 pounds) and snout-to-vent lengths of about 20 cm (8 inches), the San Esteban Island chuckwalla (*S. varius*) can exceed 1.8 kg (4 pounds) in weight and has been measured at almost 33 cm (13 inches) snout-to-vent length, with overall lengths exceeding 61 cm (24 inches)!

The home of this "giant" chuckwalla, San Esteban, is a deep water island 42 km^2 in area located in the midriff island series of the Gulf of California (also known as the Sea of Cortez). This chuckwalla is listed as endangered by the United States Fish and Wildlife Service and is on Appendix I of CITES. *Sauromalus varius* is sometimes utilized as food by Seri Indians and Mexican fisherman, but its general decline in numbers in recent years is probably due to collection for commercial purposes. Today, the total population is estimated to be less than 4,500 individuals that are concentrated in one relatively small, easily accessible arroyo. The island itself has excellent anchorage. Therefore, this species is vulnerable to further exploitation.

The San Esteban Island chuckwalla differs in more ways than just its larger size from *S. obesus.* There is very little sexual dimorphism (visual difference) between males and females. Both sexes have the same color pattern and are similar in size. The only external physical differences are that

males have enlarged femoral pores and wider necks than females. Reproduction strategies also vary considerably between species. *Sauromalus varius* females nest only about once every four years, with only eight percent of the adult females nesting in any given year. In contrast to *S. obesus,* which exhibits no parental care, *S. varius* females will actively defend their nest sites against other nesting females for several weeks after laying. Clutch size is also larger, with 18 to 30 eggs, averaging 40 mm long by 28 mm wide and weighing 18 g, laid in a 60 to 80 cm deep burrow. Hatchlings are large (but not as large as you might expect considering the differences in adult size), averaging 75 mm snout-to-vent length and about 14 g in weight. They grow at almost 2 1/2 times the rate of *S. obesus* juveniles, however, averaging 0.25 g per day.

Howard Lawler with a cold-blooded companion at the Arizona Sonora Desert Museum. *Photograph: Thomas A. Wiewandt.*

Captive Chuckwallas

Chuckwallas have had a reputation for being somewhat difficult to keep in captivity. Although requiring specialized care, they may be expected to live eight or nine years in captivity if proper conditions are met. I suspect their potential life span may be twice that long.

Young animals often adjust to captive conditions better than adults. A cage at least 4 feet by 2 1/2 feet by 2 1/2 feet is recommended for an adult pair of *S. obesus.* Basking sites under full-spectrum lighting can be constructed by stacking flat rocks on top of one another to form a sloping rocky shelf. Crevices can be left between the rocks to provide hiding spots and retreats. Rocks may need to be glued in place, because adult chuckwallas are very strong and may tumble loose stones over. Day temperatures should reach 85 to 100 °F and may be obtained through use of sunlamps, spotlights or, better still, natural sunlight in outdoor enclosures. Night temperatures may drop to about 70 °F. Water bowls should not be left in the cage, but only offered twice a week to keep humidity levels low.

Captive diets should include as many natural food plants as possible. In areas where these are not available, chuckwallas will often accept chopped mustard greens, kale, collards, grated carrots, zucchini, yellow squash, cut bell peppers and green beans. A small amount of fruit may be offered, including cactus apples, grapes, strawberries, blueberries and bananas. Other foods accepted are alfalfa hay, dandelion flowers and greens, and hibiscus flowers.

A plant protein level of about 10 percent is considered adequate for chuckwallas, and little or no animal protein is necessary for proper growth and development. A small number of fortified crickets or other insects fed sparingly is perfectly acceptable, however. Daily feedings of the vegetable mixture are recommended, but offering food every other day is also acceptable.

Twice per week, a vitamin/mineral supplement should be sprinkled onto the vegetable mixture. It is particularly important that animals that are not allowed access to natural sunlight receive proper levels of vitamin D_3 supplementation, as well as calcium, in their diet.

Currently Recognized Taxa of the Genus *Sauromalus*

- *Sauromalus ater ater,* Dumeril. Distribution: The islands of Espiritu Santo, Partida, San Jose, San Francisco, San Diego and Santa Cruz in the Gulf of California.
- *Sauromalus ater klauberi,* Shaw. Distribution: Santa Catalina Island in the Gulf of California, Mexico.
- *Sauromalus ater shawi,* Cliff. Distribution: San Marcos Island in the Gulf of California, Mexico.
- *Sauromalus australis,* Shaw. Distribution: Southeastern Baja California, from Punta San Gabriel south to La Paz, Mexico.
- *Sauromalus hispidus,* Stejneger. Distribution: The islands of Angel de la Guarda, Smith, Pond, Granite, Mejia, San Lorenzo Norte and San Lorenzo Sur in the Gulf of California, Mexico.
- *Sauromalus obesus obesus* (Baird). Distribution: Desert areas of southern California east of the mountains, extreme southern Nevada and southwestern Utah, and western and central Arizona, United States.
- *Sauromalus obesus multiforminatus,* Tanner and Avery. Distribution: The Colorado River area from Glen Canyon Dam in northern Arizona, northeast to just north of Hite in southern Utah, United States.
- *Sauromalus obesus townsend,* Dickerson. Distribution: Tiburon Island in the Gulf of California and the adjacent coast of western Sonora south to Guaymas and inland to Hermosillo, northwestern Mexico.
- *Sauromalus obesus tumidus,* Shaw. Distribution: Southwestern Arizona and adjacent extreme northwestern Sonora, northwestern Arizona.
- *Sauromalus slevini,* Van Denburgh. Distribution: The islands of Monserrate, Carmen and Coronados in the Gulf of California, western Mexico.
- *Sauromalus varius,* Dickerson. Distribution: The islands of San Esteban, Lobos and Pelicano in the Gulf of California, western Mexico.

Howard Lawler, Curator of Small Animals at the Arizona Sonora Desert Museum (A.S.D.M.), has established one of the most successful breeding programs in the world for *Sauromalus* species. Animals there are maintained in large outdoor enclosures that not only allow them access to a natural photoperiod and beneficial sunlight but are spacious enough for the chuckwallas to establish a somewhat natural social organization that may be helpful in stimulating successful courtship and breeding behavior. Eggs laid in these enclosures are not removed, but left in place to incubate under fairly natural conditions. Eggs left in the nest chambers have had as high, or higher, a successful hatch rate as ones that were incubated artificially.

As soon as the hatchlings begin feeding, they are offered a small amount of feces from a healthy adult chuckwalla in order to introduce proper microflora to begin efficient digestion. Young that were not inoculated this way grew much more slowly and did not thrive. Chuckwallas, like other herbivore lizards, are hindgut fermenters and require both the proper microorganisms and sufficiently high temperatures to break down the roughage they consume. This is necessary before their bodies can utilize the nutrients contained within the food. Their droppings are elongated cylindrical pellets containing plant fibers and are often deposited around their favorite basking sites.

According to Frank and Kate Slavens' "Reptiles and Amphibians in Captivity-Breeding-Longevity and Inventory Current January 1, 1992," there were 210 chuckwallas held in 27 reporting institutions worldwide. This, of course, is only a portion of the total number actually in captivity in both public and private collections. Of those 27 institutions, only three reported the successful hatching of a total of 17 offspring in 1991. Four *S. obesus* were produced at the Royal Rotterdam Zoological Garden; three *S. o. obesus* (western chuckwallas) at Riverbanks Zoological Park, and three *S. o. tumidus* (Arizona chuckwalla) and seven *S. varius* (San Esteban Island chuckwalla) at the Arizona Sonora Desert Museum. A *S. varius* hatched at A.S.D.M. and held at the Rio Grande Zoo for many years holds the current

longevity record in captivity at 11 years, four months (hatched 9/81, died 1/93).

Few medical problems have been associated with the captive maintenance of chuckwallas. Mites (*Hirstiella pyriformis*) have been identified on both wild and captive *S. varius*. Occasional animals have developed stomatitis infections from which the bacteria *Pseudomonas* and *Neisseria* have been isolated. Abscesses from 1 to 6 mm in size have been found on wild-caught chuckwallas. These abscesses were cultured and found to contain bacteria of the genus *Serratia*.

Although captive maintenance and reproduction of chuckwallas presents a challenge, it is being accomplished with increasing frequency and can be very rewarding. Should you wish to work with *Sauromalus*, it is easier to begin with young individuals, because they often adjust better to captive conditions than do adults. Please remember that many chuckwallas are protected by state laws that place strict bag and possession limits on them, as well as require valid licenses and regulate methods by which they may be captured. Never use a pry bar or other method to break apart rock piles. This is extremely destructive to chuckwalla habitats. As always, it is best to try to acquire captive-bred animals. They acclimate easily to a captive environment and often thrive under these artificial conditions.

Acknowledgments

Many thanks to Howard Lawler of the A.S.D.M. who took time out of his busy schedule to provide much of the husbandry information contained in this article. Howard has pioneered successful captive breeding programs for several species of *Sauromalus*.

Suggested References

Case, T. J. 1982. Ecology and evolution of the insular gigantic chuckawallas, *Sauromalus hispidus* and *Sauromalus varius*. Pp. 184-212 in: Iguanas of the World: Their Behavior, Ecology, and Conservation. Noyes Publications, Park Ridge, New Jersey.

Etheridge, R. E. 1982. Checklist of the iguanine and Malagasy iguanid lizards. Pp. 7-37 in: Iguanas of the World: Their Behavior, Ecology and Conservation. Noyes Publications, Park Ridge, New Jersey.

Lawler, H. E. and J. L. Jarchow. 1986. A captive management plan for large iguanine lizards using the San Esteban chuckwalla *Sauromalus varius* Dickerson as a model. Pp. 137-156 in: Proceedinqs of the 9th International Herpetological Symposium on Captive Propagation and Husbandry.

Ryan, M. J. 1982. Variation in iguanine social organization: Mating systems in chuckawallas (*Sauromalus*). Pp. 380-390 in: G. M. Burghardt and A. S. Rand (eds.), Iguanas of the World: Their Behavior, Ecology, and Conservation. Noyes Publications, Park Ridge, New Jersey.

Slavens, F. L. and K. Slavens. 1992. Reptiles and Amphibians in Captivity-Breeding-Longevity and Inventory Current January 1, 1992. Slaveware, Seattle, Washington.

Stebbins, R. C. 1985. A Field Guide to Western Reptiles and Amphibians, second edition. Houghton Mifflin Co., Boston, Massachusetts.

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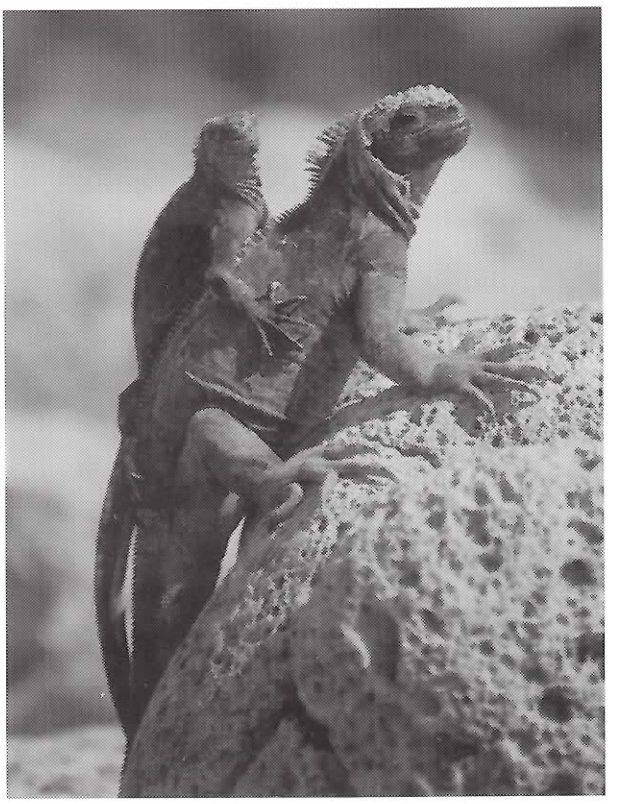
John G. Shedd Aquarium Research Expedition—October 22-29, 1995, to study endangered *Cyclura cychlura figginsi* in the Exuma Islands, Bahamas, aboard the Aquarium's research vessel, the R/V Coral Reef II. Opportunities for snorkeling, swimming, photography, exploring. Cost: $1,425, plus airfare. *Leader*: Chuck Knapp. *For more information*: Contact Amy Ihde at (312) 939-2426, ext. 3311.



Crisis in the Galapagos

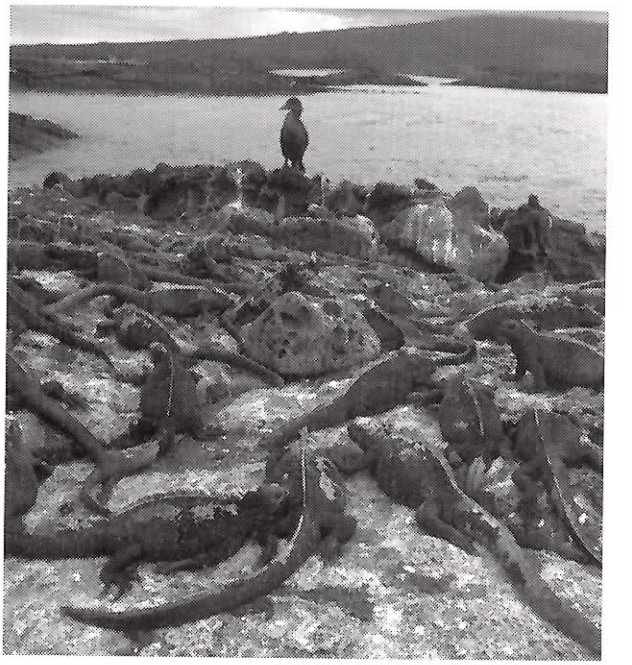
Jack Grove
President, Conservation Network International, Inc. 146 N. Sunrise Drive Tavernier, Florida 33070

Masked Ecuadorian fishermen (calling themselves "pepineros" or sea cucumber collectors), armed with clubs and machetes, seized control of the Charles Darwin Research Station (CDRS) and the facilities of the Galapagos National Park Service on Tuesday, January 3, 1995, in the community of Puerto Ayora, Galapagos. The launch of the CDRS was sunk and access to and from the airport was cut off by the vindictive pepineros. The seizure lasted three days.

The CDRS and Park personnel were confined to buildings. Those who live within the Park and Station campuses were rarely allowed to leave. In effect, the two institutions, their staffs, the facilities and the breeding groups of giant tortoises and land iguanas were held hostage. The fishermen threatened to kill tortoises and set fires on the islands if their demands were not met. Apart from a broken arm and an unconfirmed report of an unexploded bomb in a Park Service boat, the level of violence has attracted only minimal attention in the international press.

Captive breeding programs have been successfully carried out at the CDRS for both the giant tortoises and land iguanas for many years. This program was initiated for re-stocking the reptiles on their respective islands, many of which have been plagued with introduced rats, dogs, cats, pigs and goats. The reptile breeding program is one of the many success stories of the CDRS. The threat posed, when violent fishermen took over the station in January, was enormous. The crisis prompted Darwin Station officials to place "Lonesome George," the famous tortoise and last known survivor of his race, into protective custody. George remains behind bars that are designed to keep people out. One hates to think of the damage that could have been inflicted if the fisherman had carried out their threats to kill George, or destroyed even a small portion of the breeding tortoise and iguana populations at CDRS.

Those who realize what is at stake recognize that if the Ecuadorian government continues to submit to the black market demands of these fishermen, the world will lose its largest virgin island (Fernandina) as well as what may be the last significant population of scalloped hammerhead sharks. In addition to shark fins and sea cucumbers, used in Chinese and French cooking and in Asian medicine, these people are also harvesting sea horses, snails, sea urchins, and the endangered black coral. They are even killing sea lions for their penises, which are being sent to Japan as aphrodisiacs!



Endemic to the Galapagos Archipelago, marine iguana populations may be imperiled by increased human activities and any fishery activities that disturb the algal communities upon which they feed. Birds such as the flightless cormorant (in background) and Galapagos penguin live nowhere else, and are likewise vulnerable to repercussions from the fisheries industry.

In recent months, Conservation Network International (CNI) has confirmed that:

- Uncontrolled lobster and fishing boats carrying chickens and/or goats (and inevitably rats and mice) are pillaging the coasts of western Isabela and Fernandina Islands. If these animals are introduced to the islands, the

ecological impact will be devastating. The fishermen are harvesting everything marketable from the sea floor, and many of them have spearguns, which are supposed to be illegal. They are also cutting mangroves for fuel to boil their catch, and there are floating brothels for entertainment.

- An "experimental" sea cucumber fishery and a shark fishing industry were endorsed by the government on June 23, 1994. A limit of 550,000 sea cucumbers was set by the authorities. No means of regulation were established, and an estimated 6 to 10 million were taken before the government finally tried to stop the "experiment."
- The CDRS made clear their opposition to the sea cucumber industry, which opened anyway. Now supported by a team of international fisheries experts, the CDRS has also expressed their ecological rationale for not introducing a sport fishing industry. Presently, the sport fishing proposal has been drafted as a "Mandato" and will soon become law, unless international pressure can stop it.
- The remains of 84 freshly killed tortoises were found on Isabela. Although no one has been apprehended, it is likely that the tortoises were slaughtered by vindictive fishermen who were angered by the closing of the sea cucumber industry.
- Immigration to support the fisheries has dramatically increased. The expanding human populations will undoubtedly stress the fragile ecosystems further.

The reason for the violence and hostage situation is that the fishermen demanded the reopening of the sea cucumber fishery. Federal troops and a promise to reopen the fishery by October, 1995, brought the crisis to an end—or has it?

Why is the government giving in to the demands of a few fishermen? Apparently there is some big money behind it. CNI has confirmed that 1 billion Sucres (approximately $40 million US) were transferred through two Galapagos banks; one fisherman cashed a US $50,000 check!

Consider for a moment how many sizable

Feral dogs greatly decimated land iguanas on the island of Santa Cruz during the 1970's. Iguana populations are now at greater risk on Fernandina and Isabela, not only from the pets of fisherman but from stowaways as well, including feral rats.

islands there are in the world that are truly virgin (i.e., unoccupied and unscathed by the effects of human presence). In the sub-Antarctic, perhaps, there may be a few islets that have no introduced mammals. But what of the tropics? Man has impacted virtually every island in the world, especially in the low latitudes. Where man has been, by accident or design, there are now rodents—or worse—left behind. Where there are feral animals, many indigenous life forms cannot compete. One of those rare exceptions has been the jewel in the crown of the Galapagos ecosystem, Fernandina, the westernmost island in the archipelago. As fate would have it, the sea cucumber fishery is now centered along the west coast of Isabela (to the east) and along the shore of Fernandina. In July of last year, the British Broadcast Corporation produced a documentary entitled, "Galapagos: Paradise in Peril," and indeed it is. In the documentary they filmed an estimated 100 sea cucumber fishermen camped on the "virgin" shores of Fernandina—where marine and land iguanas, as well as penguins and flightless cormorants, also can be found. But there is still hope: the Ecuadorian government may change their attitude in response to international pressure.

Conservation Network International will con-

tinue to support the local Galapagos naturalists who are now risking their lives to stop the exploitation. Formed in July of 1994, CNI has no employees, it has no affiliation with the CDRS, and all contributions are invested directly to the cause. Our intentions are to draw public attention to the ever escalating crisis in the Galapagos, to stop the exploitation of natural resources from the Galapagos, and to do whatever is necessary to insure the long term preservation of this delightfully unique World Heritage Site.

WHAT CAN YOU DO TO HELP?

1. Write a letter to the President of Ecuador:
   Pres. Sixto Duran Ballen
   Garcia Moreno 1043
   Quito, Ecuador

2. Send copies of the letter to CNS as well as to:

   Ab. Gustavo Gonzales
   Subsecretario de Pesca
   Quito, Ecuador

   Lic. An-nando Espimel
   Ministerior de Informacion
   y Tourismo
   Guayaquil, Ecuador

   Lic. Jorge Barba
   Director INEFAN
   Quito, Ecuador

   Sr. Director
   Diario EL COMERCIO
   Quito, Ecuador

   Sr. Director
   Diario EL UNIVERSO
   Guayaqil, Ecuador

   Lic. Arturo Izurieta Valery
   Intendente del Servicio
   Parque Nacional Galapagos
   Puerto Ayora
   Islas Galapagos, Ecuador

   Ambassador Edgar Teran
   Embassy of the Republic of Ecuador
   2535 Fifteenth St. N.W.
   Washington, D.C. 20009

3. Call your travel agent and any journalists who might be interested in this concern, and feel free to refer them to Conservation Network International.

4. Support the efforts of CNI to expand our publicity campaign and stop the exportation of shark fins and sea cucumbers from the Galapagos.

NOTE FROM THE EDITORS: We urge all interested persons to pass on copies of this sobering article; however, if reprinted in a publication, CNI requests that a copy be sent to them to help document the success of their publicity campaign.

IGUANA NEWSBRIEFS

Saga of a Lost Pet

In Port St. Lucie, Florida, a family pet iguana escaped from the screened-in back porch of the family's home during his natural mating season. The iguana, "Juan," about 30 inches long, wasn't reported missing because the family thought that he had fallen prey to cold weather or one of the cats in the neighborhood.

But two months later, Mary Morgan, the owner of Juan, recognized her old pet in a Fort Pierce pet store. Juan was distinctive because of a crippled right front claw and missing spikes on his neck. Morgan says that Juan recognized her, but looked rather sick.

The manager of the pet store said that a 12- or 13-year-old boy had sold it to him for $50. Although he was trying to sell the iguana for $100, he told her she could have it for $60 in spite of his skepticism. But she refused his offer, only to learn that the store owner had sold the same iguana on the very next day.

Morgan has been fighting to get Juan returned to her. "He's worth more than a million bucks to us," she was quoted as saying. In the meantime, she hopes her treasured pet, no longer a bright green color, will make it.

Source: Port St. Lucie Tribune

Rescue Network Benefits Iguanas

The Reptile and Amphibian Rescue Network (RARN), based in Los Angeles, California, takes ill or injured animals and nurses them back to health. They also attempt to place them in the hands of responsible adopters. From a list of their recent work, it would not surprise iguana enthusiasts to learn that iguanas comprised nearly 50% (23 of 48) of the rehabilitated pets. Due to their specific dietary needs and required exposure to UV light, iguanas in the hands of poorly informed owners are especially prone to become ill. Furthermore, many people lose interest in their pets as they grow from cute babies into adults that require more space and are less easily managed. Clearly, members of I.I.S. should work together to better inform the iguana-buying public of the responsibilities and realities of iguana ownership.

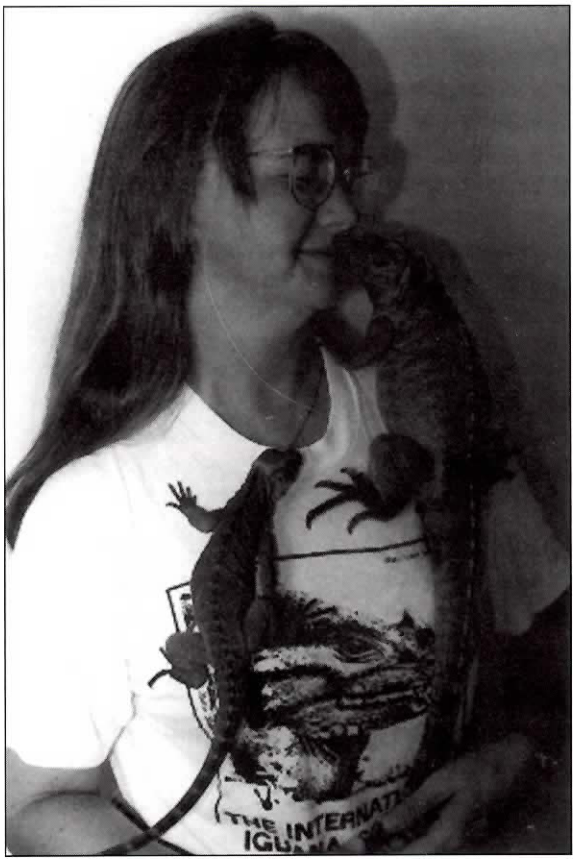
Source: Southwestern Herpetologists Society Newsletter

Uncredited Photos

In the last issue we featured several photos for which no credits were given. The two green iguanas that appeared on pages 14 and 15 should have been credited to Stephen Nordlinger, Orlando, Florida. We apologize for our oversight.

The Editors

The Official International Iguana Society T-Shirt



$12 plus $2 for postage & handling ($1 P&H for each additional shirt)

Sizes available in Small, Medium, Large, and X-Large (model and iguanas not included).

Send check or money order to:
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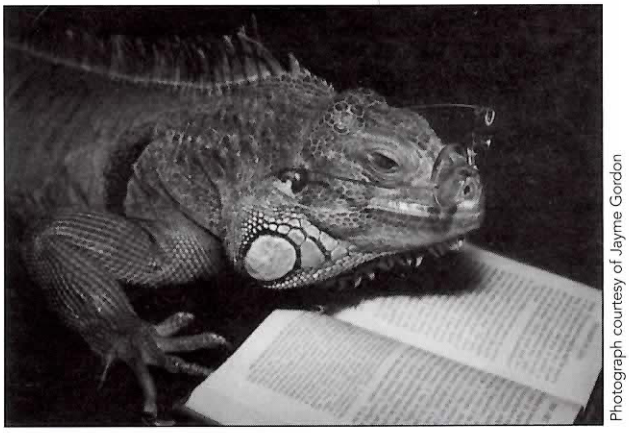
Route 3, Box 328
Big Pine Key, FL 33043

I.I.S. Bookstore



Photograph courtesy of Jayme Gordon

As a service to our members, a limited number of publications will be distributed through the I.I.S. Bookstore. The following publications are now available:

Iguanas of the World: Their Behavior, Ecology and Conservation, *Edited by Gordon Burghardt and A. Stanley Rand.* 1994. Most complete single iguana book ever written–highly recommended. 472 pp. **$60.00** (including postage); **$75.00** (non-members)

The Green Iguana Manual, *by Philippe de Vosjoli.* 1992. **$7.00** (including postage); **$8.75** (non-members)

Guide to the Identification of the Amphibians and Reptiles of the West Indies (Exclusive of Hispaniola), *by Albert Schwartz and Robert Henderson.* 1985. **$19.00** (including postage); **$27.00** (non-members)

Schwarze Leguane, *by Gunther Köhler.* 1993. **$19.00** (including postage); **$24.00** (non-members). Excellent Ctenosaur guide book, photographs, range maps, text in German.

Iguana Times Back Issues available: Vol. 2, #2, Vol. 2, #3, Vol. 2, #4, Vol. 3, #1, Vol. 3, #2, Vol.3, #3 for $6.00 each. Add $1.00 for shipping & handling for single issues, and $2.00 for 2 or more issues. *All other issues are currently sold out, but may be reprinted in the future.*

Send check or money order (payable to International Iguana Society) **to:**

I.I.S. Bookstore
Route 3, Box 328
Big Pine Key, FL 33043

Statement of Purpose

The International Iguana Society, Inc. operates as a non-profit, international organization dedicated to the preservation of the biological diversity of iguanas through habitat preservation, active conservation, research, captive breeding and the dissemination of information.

Membership Information

Iguana Times, the journal of The International Iguana Society, is distributed quarterly to members and member organizations. Additional copies are available at a cost of $6.00 including postage. Annual dues for The International Iguana Society are $25.00 for individuals, $35.00 for foreign memberships, and $35.00 for organizations, which receive double copies of the journal.

Write to:
The International Iguana Society, Inc.
Department of Biology
Southern College
Collegedale, TN 37315

Solicitations

Members of the I.I.S. are encouraged to contribute articles, letters to the Editor, news items and announcements for publication in *Iguana Times*. General articles can deal with any aspect of iguana biology, including conservation, behavior, ecology, physiology, systematics, husbandry, or other topics. Submission of photographs to accompany articles is encouraged.

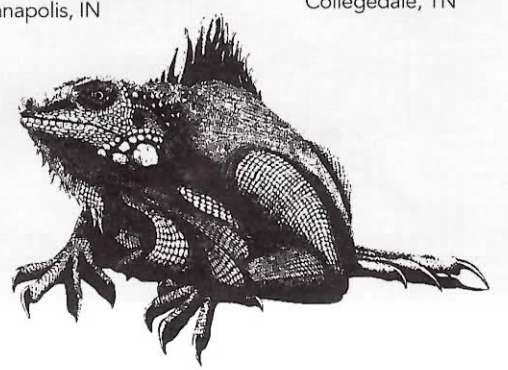
Manuscripts based on original research are solicited to communicate recent findings not only to other scientists but to the general public as well. We wish to instill in our readers a greater appreciation for scientific research and a better understanding of how it can contribute to the conservation of threatened iguana populations or the well-being of captive specimens. **Research Articles** will be subjected to peer review, and should be fairly general in scope (i.e., manuscripts having extremely detailed theoretical or statistical bases should be submitted to more appropriate journals). Manuscripts of any length will be considered, and must be accompanied by an abstract of corresponding length. Authors can expect rapid turnaround time for the reviews and quick publication of acceptable material. Research articles will be cited as appearing in the *Journal of the International Iguana Society*, and will be forwarded to the major citation and abstract journals. **Research Updates** should be comparatively brief and written in non-technical language. They will not be subjected to peer review. Submission of photographs to accompany research reports is encouraged.

All manuscripts must be typed, DOUBLE-SPACED, with 1" margins, on 8½" X 11" paper, following a format like that shown in the most recent issue of the journal. Original research articles must be submitted in triplicate. If at all possible, manuscripts should be accompanied by a disk (3½" or 5¼") containing a word-processing file of the manuscript. We support most word-processing applications in both PC and Macintosh formats. Please include file name, software name and version number on the disk; a hard copy printout is still required. Shorter articles, research updates, letters, and announcements may also be submitted to the editor via e-mail (send to hayes@southern.edu). For any contribution, please include your name, address and phone number.

Authors of one page or more of print are entitled to three copies of the issue in which their article appears. Reprints may be purchased upon request to the editor.

Advertising Policy of Iguana Times

We advertise only non-living products (except feeder insects). All products have been examined and been found to be high quality and fairly priced. Contact I.I.S., Department of Biology, Southern College, Collegedale, TN 37315, for more information.



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