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CONSERVATION AND NATURAL HISTORY

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L. LEE GRISMER

Larutia trifasciata is a denizen of upland fossorial cloudforests in peninsular Malaysia (see article on p. 256).

M. SOLÉ

Tadpoles of Darwin's Frogs (*Rhinoderma darwini*) develop in the vocal pouches of males (see article on p. 246).

COLE R. GROVER

Pale Milksnakes (*Lampropeltis triangulum multistrata*) tolerate the harsh climate of the northern Great Plains (see article on p. 230).

MIKE PINGLETON

Prairie Rattlesnakes (*Crotalus viridis viridis*) are fierce inhabitants of the Comanche National Grasslands, where dinosaurs once roamed (see article on p. 222).

ROD WITTENBERG

An entire population of Timber Rattlesnakes (*Crotalus horridus*) was relocated when their habitat was threatened by development (see article on p. 210).

Front Cover: L. Lee Grismer

Juvenile Wagler's Pitvipers (*Tropidolaemus wagleri*) often prey on lizards, including some of the smaller species of skinks. Snakes frequently wait for long periods to ambush passing skinks. See related article on p. 256.

Back Cover: Maik Dobiey (http://maikdobiey.com)

Sumatran Pitvipers (*Parias sumatranus*; formerly assigned to the genus *Trimeresurus*) are arboreal snakes found in Thailand, Malaysia, and Indonesia. The diet consists mainly of small mammals and birds.

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Increasing development in northeastern Kansas poses a distinct threat to Timber Rattlesnakes (*Crotalus horridus*) along much of the western limits of the species' distribution.

Successful Relocation of a Threatened Suburban Population of Timber Rattlesnakes (*Crotalus horridus*): Combining Snake Ecology, Politics, and Education

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Crotalus horridus has a geographic range covering somewhat more than the eastern third of the continental United States (Brown 1992, 1993; Martin 1992; Pisani et al. 1972), within which its distribution is patchy (Clark et al. 2007). This extensive area includes diverse climatic extremes to which the species has adapted successfully (Brown 1993; Martin 1992, 2002; Fitch and Pisani 2004, 2006a, 2006b). Of the several U.S. species in the genus *Crotalus*, *C. horridus* has among the most, if not the most, interactions with humans, primarily because it occurs near population centers in some of the most densely-populated areas of the country. Thus, in addition to depredation by humans hunting the snakes for bounty or commercial collection (Brown 1993, LeClere 2005), increasing development of rural areas has an impact on aggregation (den and birthing) sites as well as summer feeding-breeding ranges. This situation is not, of course, limited to *C. horridus* (Reinert and Rupert 1999, Ernst 2004; see also the introduction in Nowak et al. 2002) or, in fact, even to crotalids (Butler et al. 2005a, 2005b).

In the last two decades, increasing public education efforts by scientists conducting research on *C. horridus* and other members of the genus (Ernst 2004), along with an increasing ecological awareness by the general public, has resulted in an attitude shift (however slight) toward increasing tolerance of the species' frequent occurrence alongside human activities (Brown 1993). Nonetheless, increasing development (especially in northeastern Kansas, which generally lacks the physiographic barriers to development found

ROD WITTENBERG

A large adult male Timber Rattlesnake (*Crotalus horridus*). The red paint on the basal rattle allows for individual recognition without handling the animal.

ROD WITTENBERG

Like other species of snakes inhabiting areas experiencing human encroachment, Timber Rattlesnakes crossing roads or thermoregulating on warm pavement are vulnerable to vehicular traffic.

ROD WITTENBERG

Although Timber Rattlensnakes usually are considered to be terrestrial species, arboreal behavior is not uncommon.

in many eastern states) poses a distinct threat to this species along much of the western limits of its distribution (Fitch 1999, Pisani and Fitch 2005, Edwards and Spiering 2005), which remains little-known in this part of its range despite 56 years of earlier snake research in the area (Fitch 1999). The species is classed as SINC (Species in Need of Conservation) by the Kansas Department of Wildlife and Parks; however, that listing, used in other states as well (e.g., Adams 2005), carries no legal protections for the species or its habitat.

Timber Rattlesnakes are highly secretive, which, along with their well-known generally inoffensive disposition (Ditmars 1936, Sealy 2002) and the relative infrequency of envenomations from snakes encountered in the wild (e.g., Keyler 2005), perhaps has contributed to their suburban survival. Where the snakes occur in proximity to human development, sightings often cause alarm for residents who are concerned for the safety of humans and pets. Often, snakes discovered close to human habitation either are killed or are removed by local animal control personnel. In most instances, sightings close to human habitation involve mature male Timber Rattlesnakes, which have larger home ranges than females or juveniles (Sealy 2002). In part, this wider ranging reflects mate searching (Clark et al. 2007).

Unfortunately but inevitably, the politics of educated, peaceful coexistence between encroaching humans and native pit vipers involve a very fragile balance. Municipalities facing the very real prospect of expensive litigation due to an envenomation (irrespective of whether the human or its pet was fundamentally to blame) occurring in a public park, golf course, or residential neighborhood most likely will strongly consider eradication of the snakes. Unlike, for example, northern New York, with large tracts of state-owned land and snake dens in sites with a geology that would prohibit development for human use, this scenario is especially likely in areas such as Johnson County, Kansas, where heavy population

JENNY REID

A Timber Rattlesnake in a residential area near the original den site.

Table 1. Public land ownership by state (from NRCM 1999).

State	% of State's Total Area	State Rank
New York	36.97	10
Pennsylvania	14.74	20
Arkansas	11.85	22
West Virginia	9.92	24
Missouri	6.02	33
Massachusetts	5.54	35
Iowa	1.04	49
Kansas	0.92	50

growth has extended city limits into the easily developed Timber Rattlesnake habitats.

Background: The Lenexa, Kansas Population.—Proposed and actual development of land within the City of Lenexa used as habitat by Timber Rattlesnakes provided an opportunity to test the effect of relocating an entire population (or at least most of one) to other suitable habitat remote from development. Lenexa Animal Control (LPD-AC) occasionally received complaints about Timber Rattlesnakes previous to 2005. However, during June 2005, one Lenexa resident contacted LPD-AC seven times to report a rattlesnake in his yard, which was part of a new development bordering a golf course. In each instance, either LPD-AC or a Lenexa Police Officer responded and removed the snake; snakes were relocated to a less residential area within 2 km of where they originated. This resident was very tolerant of the snakes, but did not want them interacting with his small dogs. His yard was well groomed — free of debris or mature landscaping. Some residents of the adjacent suburban area seemed not overly afraid of the snakes, which were not at all shy about traversing mowed grass yards in residential areas.

Construction workers on sites bordering this residence admitted to LPD-AC that they were killing additional Timber Rattlesnakes found under scrap materials on their job sites. Several rattlesnakes also were found in additional yards and dead on newly paved roads in the area. LPD-AC contacted several local resources to learn more about the occurrence of these rattlesnakes in such a high concentration; the conclusion was that the snakes most likely were moving to what was once their summer foraging habitat (meadow). LPD-AC initiated a public education campaign about coexisting with rattlesnakes, and hosted a workshop with area authorities (Joseph Collins, Dana Savorelli, and Rod Wittenberg) speaking about rattlesnake behavior, habitat, and the need for tolerance and conservation. Wittenberg and Savorelli both assisted LPD-AC in searching for local dens, but did not locate any likely sites.

DYLAN LEHRBAUM

A large male found beneath a downed road sign at the original den site.

Male and female Timber Rattlesnakes courting in a suburban backyard in Lenexa, Kansas in July 2009. Note the landscaping fabric, which in some instances can have adverse effects on entangled snakes. These photographs were taken by the homeowner.

In late fall 2006, Dorr was informed by a Lenexa City employee of a den with "hundreds of rattlesnakes." When asked for further information, Dorr was referred to another employee, Mike Shipman, who had located the den. Shipman, a city inspector, advised that he frequently observed several rattlesnakes (a more realistic number) in a specific area in early fall 2006. In February 2007, Dorr and Rod Wittenberg (University of Arkansas) evaluated the area Shipman identified as a snake den. Although the area was frozen, they determined that it seemed to be a likely location for a potentially large population of Timber Rattlesnakes. Dorr was advised of pending development of the area for a large retail center and was asked whether "it would be better to bulldoze the snakes while they were sleeping or try to destroy them after they came out of their den." Neither was a particularly tasteful or ethical option for


GEORGE PISANI

A large male Timber Rattlesnake coiled at the original den site.

Dorr or Wittenberg, who were told that work was to begin on the site in March 2007.

Dorr contacted the Kansas Department of Wildlife and Parks (KDWP) to inform them of the planned development in an attempt to stop or delay the construction. KDWP responded in late February 2007 and brought Pisani in to assess the situation. Pisani independently had investigated rattlesnake reports from a resident north of the newly impounded Lake Lenexa and an adjacent recreation area that seemed to Pisani not to have a geology that would provide suitable hibernation sites. With the new information from Dorr and Wittenberg, a decision was made to capture as many snakes as possible at emergence and to move them to a new location to test a new model for conservation relocation. Emergence of this population was expected in April and May (Wittenberg, Pisani, unpublished data). Pisani drafted a funding proposal; Dorr and Wittenberg met with the private landowner to ask for permission to remove the snakes. The landowner was tolerant of the snakes and expressed interest in the study. He granted permission for snakes to be removed from his land and agreed to delay construction on this portion of the site for as long as possible.

The threatened den site was located in ~2 ha of road rubble dumped into a northeast-facing creek valley during reconstruction of an adjacent Kansas state highway between 1980 and 1984. The rubble was capped with ~1 m of dirt fill. The periphery of the rubble dump consisted of largely exposed concrete slabs and culverts; the soil-covered surface also contained concrete culvert ends and assorted edges of concrete slabs. Depth of the rubble was ~1.5–3.0 m, and the flat surface of the dump was vegetated by grasses and forbs typical of highly disturbed roadside areas. Lacking any overstory, the surface received full insolation. While we do not know when the population of *C. horridus* initially colonized the site, the population age-size structure suggested a time period of at least 10–15 years, probably longer, based on a comparison of this population structure to that of a den being monitored by Henry Fitch and Pisani since 2003 (Pisani, unpublished data). Fitch (pers. comm.) noted that the den had been largely extirpated by construction activity in the early 1990s, but continuing studies indicated a recovered population of ~60 Timber Rattlesnakes.


BECKY COLIN

Original hibernaculum after some development in summer 2007.

Table 2. Size, mass, and survival of transmittered Timber Rattlesnakes in spring 2007. * = gravid. P = Predation, E = Exposure after successful hibernation and emergence.

Sex	Mass (g)	SVL (cm)	TL (cm)	Survival
F	519	92.0	6.4	Y
M	450	91.4	7.6	N (P)
F*	490	74.3	4.5	N (E)
M	1,248	116.0	9.0	Y
F*	409	75.3	4.4	Y
M	459	92.5	7.8	Y
F	327	74.0	5.8	Y


JENNIFER DORR

A portion of the original hibernaculum, an extensive system of road rubble, prior to development.

In addition to emerging *C. horridus*, collectors also encountered over 90 individuals of other reptiles (*Elaphe obsoleta, Terrapene ornata, Lampropeltis triangulum, Agkistrodon contortrix, Diadophis punctatus, Coluber constrictor*) using the den. This was further suggestive of a well-established community.

Background: The Arguments For and Against Moving "Nuisance" [venomous] Snakes.—The debate over the efficacy of moving "nuisance" snakes (almost uniformly venomous species), in addition to other herpetofauna, as a conservation measure has gone

on over many years, and no doubt will continue. Opinions have ranged from decidedly negative (Dodd and Seigel 1991, Reinert 1991, Reinert and Rupert 1999) to guarded optimism (Burke 1991, Sealy 2002, Ernst 2004, Butler et al. 2005a). In some instances, relocation efforts somewhat magnified the initial problem (Butler et al. 2005b). Dodd and Seigel (1991) made the well-taken point that "... the burden of proof is on the investigator to show that a self-sustaining population [has been established] before declaring success." This can be difficult to evaluate if snakes are simply relocated into another population. Additionally, as more than a few threatened herpetofaunal populations are of species with lengthy life spans and prolonged reproductive cycles, well-planned relocation efforts often might be based upon less than unequivocal indications of success.

Over the timeline of the debate, much has been learned about the behavioral characteristics of snakes in general, including a considerable body of literature on crotalid social behavior (e.g., Cobb et al. 2005, Clark et al. 2007, Clark 2004, Aldridge and Duvall 2002, Weldon et al. 2002). Additionally, the various arguments against the practice of relocation (by any of its synonyms in the citations above) sometimes have been broad with respect to taxa, and have included taxa with widely disparate dispersal potentials (e.g., Burke 1991).

The concerns advanced in the references cited above, as well as others, have elucidated some basic concerns that conservationists interested in such efforts must consider. These are: (1) Relocations ideally should not be made into an extant population with an established social order; (2) As a corollary, relocations of individuals of a social species should be implemented in a way that does not force the relocated animals to survive the stresses that may be attendant to fitting into an established social structure; (3) Investigators should not relocate individuals or populations of vagile species (i.e., fish to a different drainage, birds, insects, etc.) in a way likely to contaminate the genetic makeup of other populations; (4) Investigators should ascertain the suitability of habitats to their species-of-question prior to the relocation.

In all instances we have found and cited variously in this introduction, several underlying similarities, which in light of the above-mentioned gains in knowledge of snake biology, seem to have contributed to the results reported by others. These are:

(1) Nuisance snakes were collected at varying times of the year (and published reports sometimes have encompassed snakes relocated at different times through several years of a study) based upon their occurrence in human habitats where they caused alarm;
(2) Snakes generally were collected/moved singly without regard to naturally occurring family groups;
(3) Snakes were sometimes transported many km from their sites of capture (8–172 km in Reinert and Rupert 1999);
(4) Snakes were relocated into established conspecific populations (and thus social structures);
(5) Release micro-sites at the new location were not chosen with regard to foraging or hibernation habitats the snakes would need for survival;
(6) Snakes were not necessarily handled in ways that minimized stress prior to relocation.

Several published reports among those we cited above indicated that distant relocation of individual snakes usually results in the death of the animal, either by failure to locate shelter from predators in the new area or a failure in fall to locate suitable hibernation sites. We do not find this surprising given the current knowledge of crotalid sociality. Snakes taken from varied family groups at times well after egress and deposited into a resident population that has its own established social order probably would be subject to considerable expenditures of energy devoted to resource-orientation, and also substantive exposure to predation through increased movement. Particularly instructive is the notation by Reinert and Rupert (1999), who indicated that by September 1991 (the second season of their study), some translocated snakes were observed to have formed associative relationships with each other and with residents.


PAIGE HOUGHTON

The senior author tracking rattlesnakes with implanted radio transmitters.

Predation losses alone may not always be a good indicator of relocation failure. So, while increased movement surely does factor into snake vulnerability, Fitch and Pisani (2004, 2005) experienced close to 50% predation loss of transmitter-bearing Timber Rattlesnakes in a resident population, most probably (Pisani, unpublished data) from avian predators (Red-tailed Hawks or unknown species of owls). Such high losses in areas with high populations of relatively large raptors (or particularly adept ones — Fitch and Pisani 2005; Ernst 2008, pers. comm.) may not be unusual. Because relocation efforts of less than 20 km may well mean that the relocation site still is very vulnerable to human incursion, we question the weighting of all anthropogenic mortality causes equally, or equal to losses from natural predation. So, for example, extensive daily movements of a disoriented relocated Timber Rattlesnake may result in its abandoning species-typical road-avoidance behavior (Andrews and Gibbons 2005), and its death as a roadkill can be attributed to that behavior. However, if humans aware of the chance of finding snakes at a relocation site do so and kill one or more of the snakes, we view that as unfortunate but not as mortality that necessarily detracts from the success of the relocation.

Telemetry is a time-intensive methodology. Consequently, most relocation studies, in addition to the variables discussed above, have used reasonably few specimens, and have not always had comparative samples available. An exception is Nowak et al. (2002). They conducted a limited but rigorous experimental test of the effects of translocation on *Crotalus atrox*. Even so, snakes were relocated to the new site at varying times of year and not necessarily from the same family group.

While single-specimen relocations are acknowledged to generally fare poorly, we hypothesized that capture of all available adults and young upon emergence from a single den in spring and relocating them to suitable other habitat would result in minimal population disorientation, stress, and concomitant losses. We further hypothesized that, as *C. horridus* largely orients by scent-trailing (especially young following adults — Weldon et al. 1992, Cobb et al. 2005), mass-reintroduction during the spring to a rock formation suited to future hibernation would allow dispersion of adults (to feeding and birthing grounds), effectively establishing scent trails that would lead back to the new den site in the fall. We felt that a relocation thus timed would give snakes the best opportunity to orient to new habitat during warmer weather.

Our model was developed using the knowledge that *C. horridus* is a long-lived (Brown 1993 and pers. comm., Pisani and Fitch 2002) and highly social (Cobb et al. 2005, Clark 2004, Aldridge and Duvall 2002, Weldon et al. 1992) species. Our underlying belief was that, if a considerable number of snakes from a den could be captured upon first emergence in spring, kept together, and then released together into a suitable denning/foraging/birthing habitat several km (but <20 km) distant from their original den, they would reorient and establish themselves as a group in the new site.

Methods

Several potential release sites were assessed by Pisani and Dorr during February and early March 2007 using the following criteria:

- Presence of a limestone stratum that weathered to produce deep fissures, with rock fractured by apparent mechanical weathering plus penetration of tree roots, and having several crevices with surface openings >6 cm in width;
- Southerly (SE–SW) exposure;
- Adjacent grassland and forb fields (natural and/or cultivated) that, combined with edge habitat, would support an abundant population of small mammals (potential prey species);
- Abundant edge habitat;
- Nearby sources of permanent water;
- Minimal nearby human development;
- Land owned by a county or municipal government (and thus protected from development) that would agree to host the project;
- No known extant population of *C. horridus*;
- Readily accessible to the research team for tracking.

In general, the site sought was to reflect the characteristics of the habitats used by *C. horridus* studied by Fitch and Pisani (2004, 2005, 2006a, 2006b). All but one were rejected for failure to meet all of the criteria. The site selected for the release was not known to have a resident population of *C. horridus* (Thompson, pers. comm. to Pisani; Pisani, personal observation), and was a few kilometers from the original den location.

The forested portion of the site is dominated by mature Chinquapin (*Quercus muehlenbergii* and *Q. prinoides*) and Burr (*Q. macrocarpa*) oaks and Shagbark Hickory (*Carya ovata*), which is typical of Timber Rattlesnake habitat in Kansas (Fitch 1958). The prairies are characterized by Big Bluestem (*Andropogon gerardii*) as well as Prairie Pepper (*Lepidium densiflorum*), Cord (*Spartina pectinata*), Switch (*Panicum virgatum*), Indian (*Sorghastrum nutans*), and Kentucky Blue (*Poa pratensis*) grasses, and dotted with prairie forbs such as various sedges (*Carex* spp.), asters (*Aster* spp.), and milkweeds (*Asclepias* spp.). This oak-hickory forest interspersed with open areas provides extensive ecotonal zones, ideally flanked by shelter and basking habitats. In order to further characterize these microhabitats, we assessed the density and diversity of prey (small mammal) species by placing three parallel grids comprising 100 total Sherman traps. The area sampled was an approximately 230 x 110-m (25,500-m^2) tract of land encompassing three distinct types of habitat. One-third of the traps were situated in the forest, one-third in the edge zone, and the remainder in the prairie. Traps were set in the afternoons and checked for three consecutive mornings, and mammals were marked with temporary designations. The traps were then allowed to lie fallow for one night, followed by two additional days of trapping. The Bailey-modified Lincoln-Peterson (Bailey 1952) index was employed to approximate the population density of each species, and Margalef's *d* (Margalef 1958) and Shannon's diversity (Shannon and Weaver 1949) indices were used to assess small mammal community structure.

Following a protocol training session by LDP-AC, snakes were captured by investigators and trained volunteers at the Lenexa den site in April 2007, and were processed as follows: (1) Marked by unique scale-clips (scales saved for pending DNA analysis) and sub-

Rod Wittenberg, University of Arkansas, conducts a training session for persons involved with this study.

MINDY WALKER

Habitat at the relocation site. A large male was found beneath these logs soon after release.


GEORGE PISANI

Hibernaculum at the release site in the relocation area. Note the fractured, southwest-facing limestone outcrop in mature Oak-Hickory forest.

cutaneous implantation of a Passive Integrated Transponder (PIT) RFID tag (AVID Systems); (2) Collected population data on sex, body sizes, mass, etc; (3) Implanted transmitters into selected snakes so their movements and survival could be monitored; (4) Released in one or two groups PREFERABLY by heading them into the new den hole so they could re-emerge, scent-trail the first individuals to disperse, and disperse in a pattern that, for them, would be reasonably normal.

In order to minimize stress to animals whose natural movements we planned to monitor, captured snakes were placed as gently as possible using aluminum tongs into clean plastic buckets for transport to the holding and/or surgery facilities (cf. Nowak et al. 2002). This procedure minimized handling, was safer both for the snakes (keeping stress to a minimum) and investigators, and minimized the transfer of human scent to the skin of snakes. In subsequent handling during processing, and thereafter as required during the study to assess post-release feeding or reproductive status, snakes were "tubed" by using 36-inch aluminum tongs and inducing snakes to enter rigid-wall acrylic tubes chosen to limit their ability to turn. Once the head/neck were in the tube, animals were grasped at the tube/body juncture for safe handling, which also minimized animal stress and struggling.

Twenty-nine Timber Rattlesnakes were collected and processed in 2007, and 22 were relocated to the new den site within 2–3 days of capture. The seven others were held for transmitter implantation and later release; delayed receipt of electronics and, in a few cases, waiting for ecdysis prior to surgery resulted in snakes being released at the new site anywhere between 2 days and 5 weeks after initial capture. Snakes emerging together were housed together during holding periods. In mid-summer 2007, LPD-AC was called to remove a large male Timber Rattlesnake courting a mature female in the yard of a residence. This male bore a distinctive series of dorsal scars and was recognized (Shipman, pers. comm.) as being from the den threatened with development. The female's den of origin is unknown. Site of capture was ~6 km east of the threatened den (straight line measure), and even a circuitous route for that male would have taken him through several densely populated neighborhoods. These two snakes were fitted with transmitters and released at the new site to compare their subsequent behavior with that of the group-relocated snakes moved earlier in 2007.

Surgeries were performed per the established protocol for the species (Reinert and Cundall 1982, Reinert 1992, Hardy and Greene 2000) using isoflurane anesthetic. Telemetry transmitters and associated items were purchased from Wildlife Materials International, Inc. (Murphysboro, Illinois; transmitter weight 11–12 g). Transmitter mass as a percent of snake body mass ranged from <1% to 3.5%, with an average of 2.2%. Transmitters were positioned so that their


JENNIFER DORR

Ushering a Timber Rattlesnake into a containment tube prior to processing.


ERIC KADLEC

Anesthetizing an adult Timber Rattlesnake in preparation for radio-transmitter implantation.


JENNIFER DORR

George Pisani and Mindy Walker preparing a Timber Rattlesnake for radio-transmitter implantation surgery.

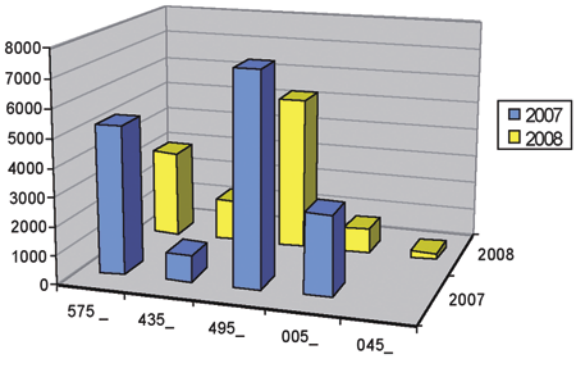
flattened surface was in contact with the snake's ventral musculature, with the flexible wire antenna extended through the primary incision, thence subcutaneously cephalad. A previously applied monofilament anchor suture around the base of the antenna wire was secured through the body musculature to prevent shifting of the transmitter and possible intestinal transfer with subsequent expulsion in feces (Pearson and Shine 2002). Snakes that were slow to recover from anesthesia were resuscitated by inserting an endotracheal tube, followed by evacuation of inhaled anesthetic by investigator exhalation into the tube according to the protocol. Snakes thereafter were kept in captivity for 24–48 hours at 21–24 °C to assure both complete recovery from anesthesia and wound closure. They then were released in groups at the new den site.

A Timber Rattlesnake report form modeled on one in use by the Natural History Division, Missouri Department of Conservation (Briggler 2001) was developed for distribution to the general public near the selected release site.

Results

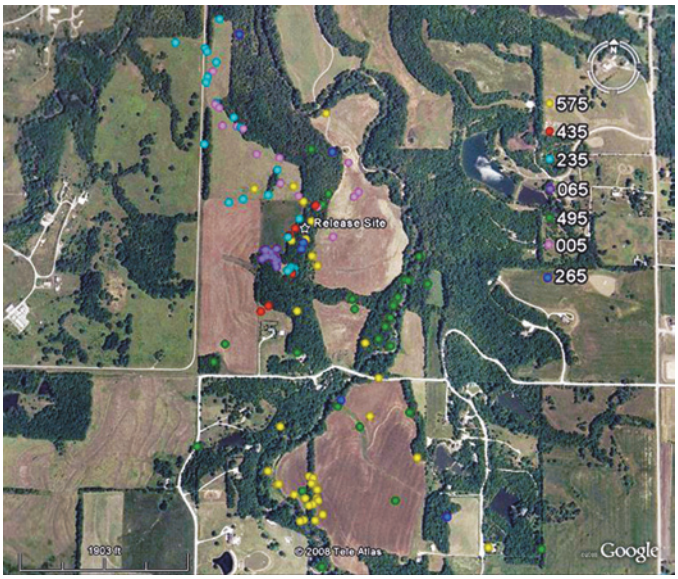
Behavior and Relative Movements.—The translocated snakes, in general, behaved as might be predicted from studies of nearby populations (Fitch 1999; Fitch and Pisani 2004, 2006a, 2006b). The aerial photographs illustrate each individual's movements throughout the first (2007) and second (2008) seasons, respectively. Snake #435 crossed into a prohibited area and could not be precisely located in 2008, but radio contact was not lost. For this reason, she was removed from statistical analyses. Circumferential foraging loop distances of the remaining five monitored snakes from both active seasons, in addition to that of a gravid snake introduced in 2008 (#045), are indicated in the graph. A paired *t*-test of foraging loop distances indicated that the 2008 foraging loops were significantly smaller ($P = 0.0007$) than those in 2007. During both seasons, snakes tended to utilize edge zone habitats more frequently than forested or prairie areas.

Table 2 indicates the measurements and survival or mortality of each of the original snakes captured during the 2007 season. One large, vagile male is thought to have joined a resident population of Timber Rattlesnakes with a hibernaculum ~2 km (1.26 mi) north of the relocation site. Despite some attrition (one snake to predation in year 1, one to exposure after successful hibernation and emergence

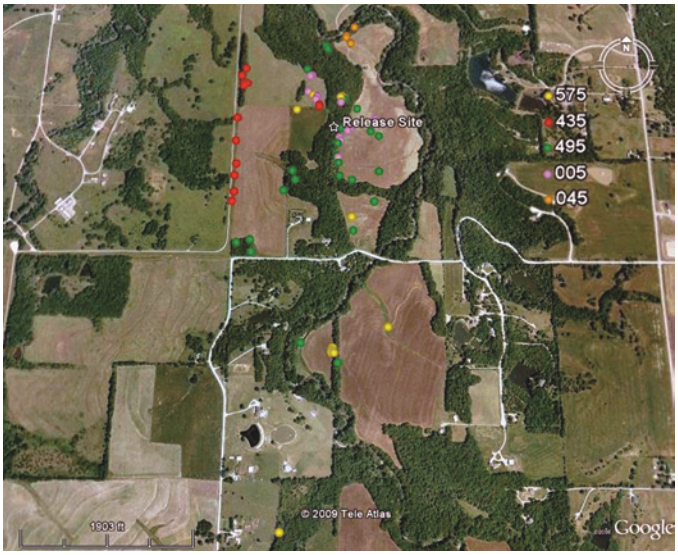


	575_	435_	495_	005_	045_
2007	5215.27	938.63	7395.13	2805.71	
2008	3079.75	1436.53	5398.24	850.35	198.85

Comparisons of the total circumferential foraging loop distances (meters) traveled by each telemetered individual during the 2007 and 2008 active seasons.



Aerial view of the release site (☆) and new habitat (1903 ft = 580 m). Each snake's foraging loop for the first (2007) active season is indicated by a different color.



Aerial view of the release site (☆) and new habitat (1903 ft = 580 m). Each snake's foraging loop for the second active season (2008) is indicated by a different color. Note that #435 crossed into a prohibited area; dots represent sites of greatest signal strengths.

in year 2), the two gravid females gave birth to an unknown number of young, perhaps as many as ten based on follicle counts at capture. Moreover, the gravid female that was added to the population in 2008 gave birth to six (observed) young.

Small Mammal Community Structure.—A total of 30 small mammals was captured and marked in the study area, with *Peromyscus leucopus* (White-footed Mouse) and *P. maniculatus* (Deer Mouse) together comprising 76.7% (40 and 36.7%, respectively) of the total captures. *Microtus ochrogaster* (Prairie Vole) and *Blarina brevicauda* (Northern Short-tailed Shrew) represented 16.7 and 6.7% of the total individuals marked, respectively. Half of the animals were captured in the prairie, whereas 33.3% were trapped


JOEY BROWN

Two-day-old Timber Rattlesnake; one of six newborns observed outside the rookery of a relocated female in September 2008.


REBECCA BENJAMIN

Female Timber Rattlesnake in the rookery in September 2008.

in the woods and only 16.7% in the edge zone. This may explain why the rattlesnakes were most commonly found in the ecotonal areas, thereby strategically affording themselves access to both habitats with the highest concentrations of prey. Small mammal density in the sampled area was relatively low, at a value of 0.001 animal/m^2. Population size estimates in this area for each species were determined to be 15 individuals of *Peromyscus leucopus*, 11 *P. maniculatus*, 6 *Microtus ochrogaster*, and 2 *Blarina brevicauda*. Margalef's diversity index, which evaluates small mammal species richness in the area, was 0.882, indicating a very taxonomically rich small mammal fauna. Shannon's diversity index, which considers evenness of the inclusive populations, was determined to be 1.75. This diversity value is typical of empirical data (commonly ranging from 1.5 to 3.5; Magurran 2004) unless vast numbers of species are sampled. Prey density and diversity values may be underestimated due to small sample size and sample area, yet these data seem to indicate a healthy population of Timber Rattlesnake prey species at the relocation site, comparable to that found in other locations (Fitch et al. 1984).

Discussion and Conclusions

Most relocation studies (including ours) have involved tracking a small number of snakes (<25) and have not included the experimental component in the design of Nowak, et al. (2002), making detailed statistical evaluation of parameters such as observed home range size tempting but basically invalid. Fitch and Pisani (2004, 2006a) found that home ranges of tracked Timber Rattlesnakes in a naturally resident population closely reflected the overall physiography of the available habitat (small tracts of open habitat transected by wooded ledges), making detailed description via various statistical constructs an unprofitable exercise for a small sample size. Additionally, the comparison of statistically described home range sizes of various authors' study populations, while having an attractive mathematical appeal, fails to integrate (and in fact deflects attention from) the question of resource availability. Thus, as any individual snake moves from a hibernaculum to an activity range each season, the annually changing resource availability it encounters (food abundance, necessary thermoregulation sites, changes in plant community growth or cover — in Kansas not infrequently altered by controlled burns, etc.) along with natural and/or anthropogenic barriers, will, we believe, determine its home range shape and size for that season. For an extensive review of the pitfalls inherent to the application of detailed statistical home-range models to small data sets see Aebischer et al. (1993).

We do not question the conclusion (Sealy 2000, 2002; Nowak et al. 2002) that short distance (<50 m) relocation of "nuisance" rattlesnakes is preferable to longer distance relocations. The authors and colleagues often have responded to rural and suburban calls regarding "nuisance" Timber Rattlesnakes, and have moved the snake 50–300 m from its point of human interaction. Usually, we tell the alarmed human we will "take the snake away." Although such snakes were not tracked, we acted in the belief that this SDT was preferable to the human killing the snake, and most incidents seem to have been resolved favorably as the encounter was purely by chance and usually does not recur.

Neither do we question the recommendations regarding the desirability of educating an encroaching human population about the probability of encountering venomous snakes in what have become shared habitats. Indeed, some outstanding successes relate to the latter (Ernst 2004, Sealy 2000) and we are developing a similar Lenexa plan with the support of the city government. We believe that, in such situations, good models for relatively short-distance relocation of populations to more secure areas (possibly supplemented by careful siting and construction of artificial dens — see Ernst 2004 re *C. viridis*) are additional valuable manage-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Newborn Timber Rattlesnake in rookery in September 2008.


LINDA LEHRBAUM

Female near her rookery (with newborns inside). The senior author is in the background.

ment tools that also can be integrated with public education. That the nature of the original Lenexa den was entirely anthropogenic is itself of considerable interest, with obvious implications for snake conservation. Augmentation or *de novo* establishment (Ernst 2004) of suitable den sites is a largely untested conservation method, but observations on the original den of our population, combined with preliminary results of Ernst (2004) and a very few others (Edwards, pers. comm.) suggest that snakes of several crotalid genera may readily accept suitable anthropogenic dens. For example, *Agkistrodon piscivorus* utilizes hibernacula in anthropogenic dam rubble and is active in anthropogenic ditches (Savitzky 2002 and pers. comm.). We here advance the suggestion that any planned new den sites be prepared in winter or spring, and then treated with whole corn and sunflower seed to more rapidly attract a small rodent (snake prey) population.

The documented high natal philopatry (Clark et al. 2007) of *C. horridus* (e.g., individuals recruit to same hibernaculum as their mother) also is valuable to conservation efforts because it suggests that successful relocation of gravid females that give birth at the new site and then den there will establish the new population. The model we employed, headstarting the majority of relocated snakes at the investigator-selected new den site early after emergence, makes use of the social characteristics of the species to reduce the stress of relocation and hopefully thereby to increase survival.

The relocated snakes ranged, survived, and behaved seasonally in a fashion that mirrors undisturbed populations within 50 km. Based upon behavior and survival of the tracked snakes through the second full activity season after relocation, during which time their foraging loops became less erratic and significantly smaller, we believe this effort has been successful, and that our results provide a more realistic definition of success than others have demanded. Our effort may have been unique in that the original den plainly was slated for destruction and suitable relocation habitat was found a reasonable (too far for the snakes to return; not so far as to cause population genetics alteration) distance away. We also hope that this relocation will provide a model for the future salvage of populations of this and related species that are threatened by habitat destruction via development. Evidence exists that much farther relocations of small colubrids can successfully establish a population (Clark 1970). Careful application of the model to crotalids deserves consideration.

The Timber Rattlesnake Report Form will be employed by personnel of the City of Lenexa and Kansas Department of Wildlife and Parks as desired to gain information on this species from the general public, as well as raise awareness of the public to the snakes as a valuable component of local ecosystems. We hope that such feedback will be useful in assessing the proximity of other populations of this species to human habitation. It also will be helpful in monitoring dispersal of released snakes.

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The footprint of a smaller carnivorous therapod is testament to a time when dinosaurs walked along the shore of an ancient lake.

TRAVELOGUE

In the Footsteps of Giants

Mike Pingleton

Champaign, Illinois

Photographs by the author.

"Here where you are standing, the dinosaurs did a dance…"

Talking Heads, *City of Dreams*

In July 2007, I found myself in Boulder, Colorado for a business meeting. This was my first visit there, and the foothills and mountains of the Flatiron Range were spectacular. How cool would it be to live and work here, I thought, with a spectacular view and hiking trails to spend lunch hours exploring? I had built a couple vacation days into my visit, and while I could easily burn them up hiking in the mountains, I had something else in mind. After my meeting was over and all of my work responsibilities met, I turned my rental car east and left the Flatirons in my rear-view mirror.

Rain clouds rolled overhead as I left Boulder and then Denver behind, heading south and then east. My destination was the northern unit of the Comanche National Grasslands in Otero County. While I was looking forward to seeing some of the amphibians and reptiles found in the grasslands of southeastern Colorado, they were secondary. My primary goal was in one of the canyons that cut deep into this country: One of the largest dinosaur trackways in the world. Under a July sun, the long hike down into Picket Wire Canyon and out again requires good physical condition, warned the website. "SOLO HIKING CAN BE EXTREMELY RISKY," it proclaimed. Perhaps, but it can also be a wonderful experience.

La Junta was the closest town, and after securing a hotel room and grabbing a quick bite to eat, I headed out to do some road cruising for reptiles as the sun set. As I drove out of town toward the grasslands, jumbo-sized grasshoppers scuttled across the asphalt in huge numbers, making it difficult to swerve and miss them all. I was sure that flocks of birds worked to collect the bounty left in the wake of passing automobiles. Nothing edible remains on the roads for very long.

I swung onto one of the gravel roads transecting the grassland unit and tried to settle into a road-watching routine. The fading hours before sunset are good times for some snake species to be

The Comanche National Grasslands.

A Bullsnake (*Pituophis catenifer sayi*) with its body in the 'kinked' position often seen in snakes lying exposed in the open (left). When approached, the snake drew up into a defensive posture (right).

active. I found myself distracted by the low, rolling hills. The grasslands were beautiful in the late, low light — yellows, golds, browns, and muted greens all pleasing to the eye. Some of the more pronounced hills showed a line of rimrock, like the exposed spine of a long-buried beast. To the west, the line of dark clouds beneath which I had passed earlier in the day rolled towards me. I was not discouraged; a little rain on a July evening could bring thirsty reptiles out on the road for a drink.

After just a few miles, I spotted the familiar shape of a snake stretched out on the road. It was a fair-sized Bullsnake (*Pituophis catenifer sayi*) with its body in the 'kinked' position often seen in snakes lying exposed in the open. I'm of the opinion that this curvy posture is an attempt to break up the 'serpent pattern' for any raptor flying overhead. I took some close-up photos until the snake had enough of me and drew up into a defensive posture, pulling its flattened head back into a striking position while inflating its body. The tail beat a vicious tattoo on the road while the other end hissed at me — a rattlesnake imitation meant to intimidate. A couple more shots and I stepped back, letting the Bullsnake boil off the road and into the brush.

The black clouds rolled overhead, and a torrent of rain and high winds soon followed. Along the storm's edge, I came across a small adult Kansas Glossy Snake (*Arizona elegans elegans*) crossing the road. At the height of the storm, as the winds drove the heavy rain sideways, a Prairie Rattlesnake (*Crotalus viridus viridus*) appeared in my headlights as it crossed the center line. After the line

Kansas Glossy Snake (*Arizona elegans elegans*).

of wind and rain had passed, I headed back toward town to grab some sleep. Along the way, I saw a number of Plains Blackhead Snakes (*Tantilla nigriceps*) drinking from the thin wash of water on the asphalt. I could imagine a great host of animals out drinking rainwater on this dark night.

In the morning, the sky was crisp, clear, and blue. Driving on the gravel road leading to the canyon, I came across another basking Bullsnake, a handsome brute worth stopping to photograph.

Plains Blackhead Snake (*Tantilla nigriceps*).

Prairie Rattlesnake (*Crotalus viridis viridis*).

These Colorado specimens were much lighter in coloration than the Bullsnakes back home in Illinois, but beautiful all the same. I left the snake stretched out in the road and continued on to the trailhead. I was somewhat concerned about the trailhead road's condition, since it was a three-mile drive along a very rough and rutted track to the gate, and I thought last night's heavy rains might have made parts of it impassable. My fears were all for nothing — the ground had soaked up every bit of the water, and it was difficult to tell that any rain had fallen. I was thankful that my upcoming eleven-mile walk would not be extended to seventeen miles.

Trailhead into Picketwire Canyon.

I parked the car and drank a liter of water, packing three more bottles and a big straw cowboy hat in anticipation of temperatures in the mid 90s. One last check of my gear and I walked through the gate and down the trail into Picket Wire Canyon. 'Picket Wire' apparently was an Anglicized version of 'Purgatoire,' the river flowing in the canyon's bottom.

The trail dropped steeply into the canyon, and I thought that it might be a tough climb back out at the end of the day. With each step down, I was walking backward through time, lower and lower, through the ages of the earth. At the bottom, the floor of the canyon rested on the limestone beds of the Jurassic. The Purgatoire River, working over long eons of time, cut these canyons to this great depth, exposing layers of rock laid down as sediment 150 million years ago. At times in the past, when the ice sheets melted, the Purgatoire was a wild torrent, scouring itself deeper into the earth. These days the river lazily curves its way across the canyon floor, a mere trickle now compared to earlier times.

I reached the canyon bottom and followed the rutted trail south and west into the main canyon. Grasses were the predominant vegetation on the canyon floor, with clumps of Cholla and wildflowers scattered here and there. It was high summer, and the air was filled with the buzz and hiss of grasshoppers and other insects. With nearly every step a grasshopper would take wing away from me, and I noted different kinds in various colors and sizes. At

A Variegated Fritillary (*Euptoieta claudia*), one of many small animals in the canyon.

A view from the trail while hiking back in time.

times, the insect drone sounded like human voices at a distance, and for a while I would look around for the people I was sure I heard. In truth, the nearest humans were many miles away, and I was quite alone in this large expanse of land. Being isolated to this degree is rare these days, and I tried to accept the solitude as a rare gift to be appreciated.

Old ranch house ruins, a reminder of the people who tried to scratch out a living in this landscape.

The Purgatoire River.

I passed the remnants of an old dwelling, with nothing left but a few crumbling walls and timbers and an old cook stove out in the yard. I supposed that a thousand years from now, humans would gaze at these ruins and wonder what life was like for the people trying to scratch out a living in this landscape. Before the cattle ranchers came here, before Mexican settlers and Spanish explorers, the original native peoples had occupied this place for a long time, and it was the river running through the canyon that made human habitation possible at all.

The trail followed the western edge of the canyon, and in some places climbed low hills. On one of these rises, I noticed markings on a pair of large upright rocks and climbed up to investigate. The smaller section had split off from the larger rock untold eons ago, and the space between the two rock surfaces was covered with petroglyphs. Many shapes marked the rocks, some of them obviously representing animals, but most were abstract symbols of some sort.

Intrigued, I stopped and spent some time examining these rock markings. Most of these symbols were made using a percussive technique — the rock was struck with perhaps a small, pointed stone, and the outer layer of rock flaked away under the impact. The rocks had a dark patina from a coat of oxidation, and the percussive flaking revealed a lighter layer of rock underneath. Some of the markings may have been far older than others, having reacquired a layer of patina. One of these caught my eye and sent my brain reeling — it was an elk or a deer, and I knew I was looking at something thousands of years old. Who had made this animal picture and why? I stood in the cleft between the two rocks, staring out at the broad river valley, wondering how things looked back then, wondering about the people who lived here. This spot seemed like a doorway into the land beyond, and these markings on the rock were full of meaning and purpose, although I was too far away in space and time to understand more than that.

I needed to be on my way again; the morning was beginning to heat up and I still had miles to go. The river made a turn away from me, wandering to the other side of the canyon, while the trail continued to skirt the foothills to the west. I passed the ruins of a small chapel, where headstones in the adjoining cemetery marked the resting places of Mexican immigrants who had lived here over a century ago. *Eugenio Padilla*, I read on one grave marker. *Abeyta Murio. Maria de la Cruz.* Their headstones were made of cement

Petroglyphs: Who made these pictures — and why?

Headstones near the ruins of a small chapel marked the resting places of Mexican immigrants who had lived here over a century ago.

and were decorated with incised patterns around the names and dates. I wondered who would be reading them a thousand years from now.

This place clearly had more to offer, and I could spend the entire day wandering about in search of petroglyphs and ruins and never reach my destination. I needed to get my head out of the historic, if I was ever going to get to the prehistoric. I put my feet back on the trail and moved along at a steady pace. I was thankful for the straw hat on my head, and several times I ducked beneath small cedar trees to enjoy a few minutes out of the sun and drink a little tepid water.

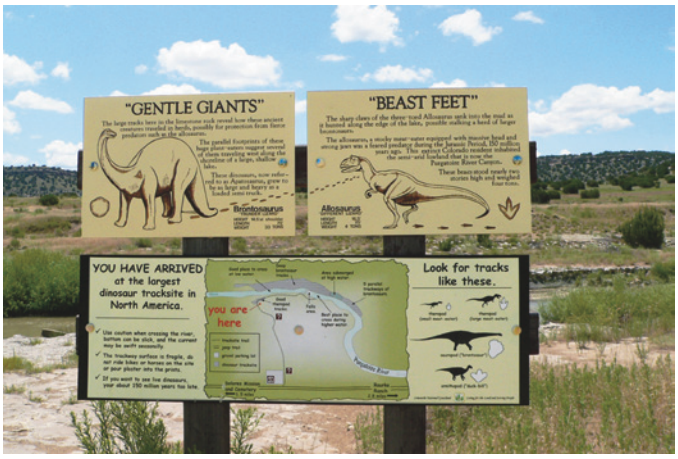
Ahead in the distance, I spotted a sign of civilization, a building, the small size and protruding vent pipe clearly marking it as a toilet. I apparently had arrived, and the outhouse had shown the way! A Red-Lipped Prairie Lizard (*Sceloporus undulatus erythrocheilus*) cocked an eye at me from a shaded overhang as I passed by the structure. Heading toward the river, I spotted some interpretive signs, well made and quite detailed. I was surprised at both the signs and restroom facilities, given the remoteness of the place. How many people came to see this? More than I thought, apparently, but today I had the place to myself. The displays thoughtfully provided an overhead map of the trackways and shapes for each type of dinosaur print. Therapods were represented by prints of the fearsome *Allosaurus*, and *Apatosaurus* was the largest sauropod to have left its tracks. Armed with these search images, I headed down toward the river. The Purgatoire had exposed these trackways, washing away the layers of sedimentary rock that had accumulated since the Jurassic.

I scanned the ground as I walked, looking for the first footprint. Hmm... Was that one? Three projections, the middle one longest … big … must be an *Allosaurus*! I don't know why I thought these tracks would be as clean and sharp as a coon's paws in mud. The markings were indistinct and rough around the edges, mud turned to rock so long ago it was hard to wrap my mind around the concept of how much time had passed. Many of the prints were filled with mud from the last overflow of the river, giving them a surreal, made-yesterday look.

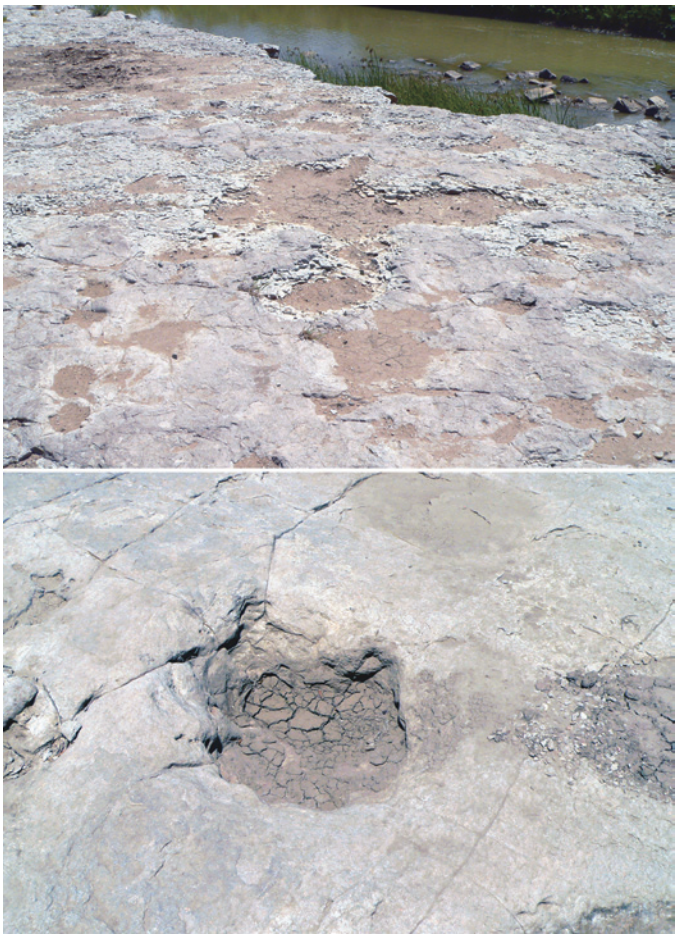
Over there … a few round potholes — *Apatosaurus*! These tracks were perhaps the diameter of a telephone pole, and a bit deeper than the allosaur print. Sitting in one of them was a Texas Horned Lizard (*Phrynosoma cornutum*), turning her head to watch me approach. The irony of that moment was delicious — modern lizards in the Age of Mammals are a far cry from what walked here in bygone days. She skittered away, but I scooped her up for a closer look and a picture or two. I then gave the little lizard her freedom and she scurried under a bush to examine me from a safe position.

The majority of the tracks were on the other side of the river, so I carefully made my way across. The water wasn't very deep, but the rocks were slippery with moss and algae. This would be a very bad place to break a leg; people knew where I was, but help could still be a long time coming. On this side of the river, more rock strata remained, telling a story of the role of frost and flood in exposing the footprints. On top was a hard layer of rock, perhaps a foot thick, and underneath it was a thin, softer layer, no thicker than a few inches. It was this thin layer that had filled in and covered up the footprints shortly after they were made. Whether this layer was mud or volcanic ash, I could not tell. As the river washed away at the thin layer, the hard, thick layer on top would fracture along regular planes and fall away as rectangular blocks. During times of heavy flooding, the force of the water would wash these blocks away, along with the softer layer underneath. Now the layer

A Red-Lipped Prairie Lizard (*Sceloporus undulatus erythrocheilus*) cocked an eye from a shaded overhang.



Interpretive displays thoughtfully provided an overhead map of the trackways and shapes for each type of dinosaur print.



An *Allosaurus* footprint (top) and those of an *Apatosaurus* (bottom).

composing the prints and trackways was exposed, and taking its turn under entropy's grindstone.

A hundred and fifty million years ago, dinosaurs walked along the shore of an ancient lake, their feet leaving depressions in the soft mud, which then dried in the sun. Not very long after, some event occurred that resulted in the depressions getting filled with another layer of soft material, fortunate happenstance for hominids happening on the scene much, much later. Timing is everything — had I visited a million years earlier, the prints might still be under layers of rock. If I were to make the long hike into the canyon a million years from now, the layer of prints would probably be washed away. I was in the right place, at the right time.

Heading upstream, I was able to find several *Apatosaurus* trackways that ran more or less parallel to the river. Who could visit here and not try to picture the scene in their mind's eye as the giant sauropods made these footprints? I sat on a big rock, drank some warm water, and tried to picture the muddy shoreline of an ancient shallow lake. The steep hills and canyon walls around me were not here back then — all that material was laid down later, and only the action of the river washed it away in this one spot.

My mind flashed back to one of the petroglyphs I had seen earlier in the day, a series of staggered circles. Could they represent these *Apatosaurus* tracks? What did those early peoples think of this place? Did they wonder what kind of creatures could leave tracks in solid rock? This had to be a place of great mystery to them. Perhaps the therapod impressions made them think of giant birds; maybe the brontosaur tracks brought mammoths to mind. Along with thunder beings and various monsters, the big hairy elephants were

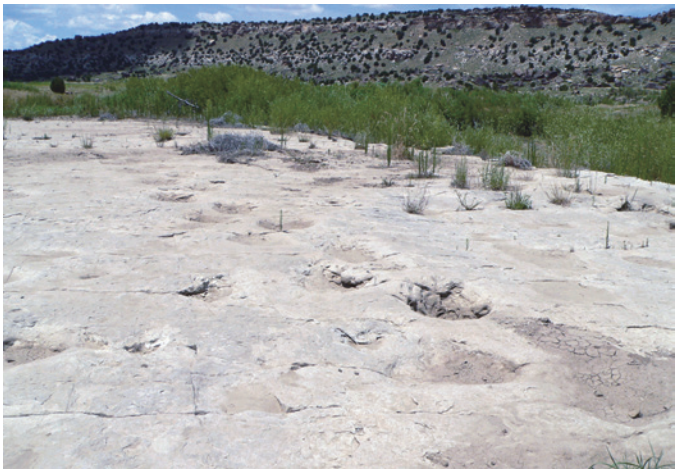
The Purgatoire River, with trackway at the far right.

A Collared Lizard (*Crotaphytus collaris*) on a block from the layer covering the footprints.

a part of Native American folklore long after they had disappeared from the landscape.

I spent several more hours scrambling about the place, taking pictures and chasing the occasional lizard while I pondered and puzzled over what I was seeing. I had drunk half of my water, and the afternoon was getting on — time for me to think about heading back. I was not looking forward to the hot five-mile walk in front of me, but I had plenty to think about as I put one foot in front of the other and headed back toward the present. Someday in the far future, the works of a certain bipedal mammal also may be buried and then uncovered in the same manner. What a rich and puzzling treasure we will leave for future bone hunters.

A Texas Horned Lizard (*Phrynosoma cornutum*) near the trackways.



An *Apatosaurus* trackway along what had once been a muddy shoreline.

A male Pale Milksnake (*Lampropeltis triangulum multistrata*) from Pennington County, South Dakota.

HUSBANDRY

The Pale Milksnake (*Lampropeltis triangulum multistrata*): Natural History and Captive Husbandry

Cole R. Grover[1] and Dell T. Despain[2]

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Photographs by the authors.

With shining scales of red, black and white, the Pale Milksnake (*Lampropeltis triangulum multistrata*) is an unmistakable, yet seldom seen denizen of the northern Great Plains and parts of the Rocky Mountain Front Range of North America. Its adaptability and tenacity are as plainly evident as its beauty.

Natural History

The Pale Milksnake is one of 25 generally recognized subspecies of *Lampropeltis triangulum*, which collectively range from Canada to Ecuador and Venezuela, and from the Atlantic Coast to the Great Basin of North America. This subspecies inhabits canyons, prairies, sandhills, semi-deserts, open pine forests, and Rocky Mountain foothills in the states of Nebraska, South Dakota, Wyoming, Montana, and likely a portion of southwestern North Dakota.

One trait these diverse habitats share is a harsh climate with hot summers, long, cold winters, and scant precipitation — all of which contribute to the largely fossorial nature of Pale Milksnakes. They are only active when conditions are optimal, and even then they are almost entirely nocturnal. Moisture, generally in the form of recently fallen rain, can stimulate surface activity in these snakes.

Observations of the Pale Milksnake are uncommon. The lack of sightings does not necessarily indicate actual population size, though various sources have mistakenly characterized this subspecies as rare. In fact, if sought under the right conditions, they can be found to be abundant, albeit secretive animals.

A male Pale Milksnake from Sheridan County, Nebraska.

Pale Milksnakes generally emerge from brumation (a period of dormancy induced by cool temperatures) in late April or early May. Upon emergence, males use olfactory cues to locate females with which to mate. Egg-laying typically occurs in late June or early July. Clutches usually consist of 2–8 elongate, leathery-shelled eggs. Hatchlings emerge from late August through early September, and measure 13–23 cm (5–9 in) in length. Pale Milksnakes re-enter brumation in late September or early October. Den sites may be shared with Prairie Rattlesnakes (*Crotalus viridis*), Eastern Yellow-bellied Racers (*Coluber constrictor flaviventris*), Bullsnakes (*Pituophis catenifer sayi*), and garter snakes (*Thamnophis* spp.).

Pale Milksnakes are dietary generalists, feeding on a variety of small rodents and reptiles. Hatchlings often show a marked preference for lizards. The snakes are in turn preyed upon by birds, mammals, and other reptiles — possibly including their own kind. The availability of surface water is not a limiting factor for populations of Pale Milksnakes. In addition to moisture obtained from prey items, precipitation, dew, and subsurface moisture likely all play a role in providing the animals with a source of water in more arid regions.

The Pale Milksnake intergrades with neighboring subspecies along the periphery of their ranges. In southern Nebraska and northern Colorado, it intergrades with the very similar Central Plains Milksnake (*L. t. gentilis*), and it is sometimes regarded as a clinal variant of that form. The Pale Milksnake also intergrades with the Red Milksnake (*L. t. syspila*) along the Missouri River Valley in eastern Nebraska and South Dakota. These intergrade zones are characterized by animals intermediate in appearance between the two subspecies.

A Note on Conservation: Based on our experiences and those of others, the Pale Milksnake is a relatively abundant form throughout most or all of its range. Due to its secretive, fossorial nature, as well as the remoteness and vastness of its preferred habitats, this subspecies appears unlikely to be threatened by commercial collection for the pet trade. Habitat damage and urban sprawl, however, can pose a serious threat to local populations. These animals have been found near and even in urban areas throughout their range, suggesting a resilience to altered habitats.

Description

The Pale Milksnake is a small to medium-sized snake, with adults averaging 60–75 cm (24–30 in) in total length. Scales are smooth and glossy, giving the animals a shiny appearance, and are found in 21 (rarely 23) rows at mid-body (Williams 1988). Their bodies are beautifully ringed in the typical tricolored red, black, and white shared with many subspecies of milksnake as well as relatives such as the Sonoran Mountain Kingsnake (*Lampropeltis pyromelana*) and the California Mountain Kingsnake (*Lampropeltis zonata*). The colored "rings" often are actually saddles in the Pale Milksnake, with the red rings not closing across the belly, although fully banded animals are seen from time to time.

Upon closer inspection of many individuals, it becomes apparent that the "red" actually ranges from scarlet through orange and to more earth-toned terra cotta and brick-red. The "white" can be bone-colored, cream, butter yellow, or a shade of gray, and can be immaculate (very rarely) or have varying amounts of dark pigment infused along the flanks. This dark pigment is affectionately referred to as "news-printing" by Pale Milksnake aficionados, and does not necessarily detract from the appearance of the animal. The black bands vary considerably as well. They can be very narrow or broad, and occasionally encroach on the red bands in what are referred to as "cross-overs" by milksnake enthusiasts. Pale Milksnakes from each locality where the species is found have their own "look," although considerable variation exists within each population.

A "spotted" male from Pennington County, South Dakota.

A female from Thomas County, Nebraska.

A female from Bighorn County, Montana.

With so much natural variation, hobbyists can pursue plenty of directions in their breeding projects. Many Pale Milksnake keepers are strict in keeping bloodlines pure, and only breeding animals from the same locality. A number of current breeding projects include reducing the amount of "news-printing" that develops as the individuals age, producing strongly yellow-banded snakes and reducing the head marking to produce white-headed animals. White-headed animals are particularly stunning, and a number have been found in the wild as well as in captivity. Pale Milksnakes are truly one of nature's works of art.

Captive Husbandry

Despite its reputation to the contrary, the Pale Milksnake is fairly easy to maintain for the experienced herpetoculturist. However, a number of ecological considerations must be kept in mind. The first and foremost is feeding. Many juvenile (and some adult) Pale Milksnakes show a marked preference for lizards. For this reason, hobbyists are encouraged to acquire captive-bred specimens that are established feeders on frozen/thawed rodents. A breeder offering this subspecies should be expected to provide robust, readily feeding stock, as well as valuable information on lineage and husbandry. Frozen/thawed rodents should form the basis of a captive milksnake's diet.

Occasionally, individuals may refuse to feed. While well-established, captive-bred specimens generally feed voraciously, some individuals cease feeding in late summer or early fall regardless of the temperatures at which they are kept. This is especially true of adults, and in nature this behavior is an adaptation to the harsh and early winters experienced by Pale Milksnakes. An individual caught in a sudden cold spell with a full digestive tract is likely to incur health problems. A captive animal that has gone off feed should be brumated as described in the section on breeding below. Upon warming in the spring, the animals generally resume their lust for food.

Security is another concern of Pale Milksnake husbandry. Members of the genus *Lampropeltis* are notorious escape artists, and escape-proof housing is necessary. Plastic storage containers with sturdy lids and locking mechanisms are adequate once ventilation holes have been provided. Animals should be housed separately other than during the breeding season. Security for the animals themselves is also a necessity. Overturned plates, folded newspaper, sections of cardboard, and small, plastic storage containers all work

A female (left) and male (right) from Stillwater County, Montana.

well. A hide-box filled with moist moss is frequently used by captive milksnakes, especially as ecdysis nears. Substrates should be inert, sterile, and as dust-free as possible. Readily available and frequently used options include aspen shavings, newspaper, and paper towels. Cedar and pine shavings should be avoided because of the toxic phenols they contain.

Adequate temperatures for the Pale Milksnake range from 21–32 ºC (70–90 ºF) during the active season. Access to a thermal gradient covering this range is ideal, although some herpetoculturists have had great success maintaining their entire collection of animals at or near the middle of this range. A thermal gradient can be achieved with the use of thermostatically-controlled heat tapes, cables, or pads placed under one end of an enclosure.

Breeding

Brumation is necessary for successful captive reproduction. Brumation should consist of a winter cooling period of three to five months at 5–13 ºC (41–55 ºF). Clean water and adequate ventilation are essential for brumating snakes. Animals of both sexes should be fed heavily through the active season. Beginning approximately two weeks after brumation ends, pairs should be placed together overnight several times each week until the females are noticeably gravid or cease to be receptive to males' advances. As oviposition approaches, females generally enter what is referred to as a "pre-lay shed," an ecdysis cycle that occurs one to two weeks prior to depositing their eggs.

Small, plastic storage containers (1–5 liters, depending on the size of the animal) with an appropriately sized hole cut into them and filled with dampened *Sphagnum* moss provide an ideal oviposition chamber, and an ideal moist hiding place throughout the snakes' active season. Following oviposition, eggs should be removed and incubated in damp, additive-free perlite or vermiculite at 24–28 ºC (75–82 ºF). Hatching commences approximately six to eight weeks later, depending on incubation temperature.

A female from Cherry County, Nebraska.

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A Note on the Acquisition of Stock: Although Pale Milksnakes are abundant in most habitats in which they are found, they are extremely secretive animals and considerable time, physical effort, and financial expenditure are often necessary to locate these animals in the wild. Additionally, some wild-collected individuals fail to acclimate to captive conditions and refuse to feed on readily available food sources. Parasitism is another concern when dealing with wild-collected animals, and any such individuals should undergo a full evaluation by a qualified veterinarian. If wild snakes are to be collected, be sure to obtain all necessary permits and comply with state regulations. With these issues in mind, acquiring snakes from knowledgeable captive breeders is far preferable to collecting them in nature.

The "Snake Dance" is performed even today, although this picture of a Snake Priest is circa 1890.

HISTORICAL PERSPECTIVE

Hopi Snake Handling[1]

Mischa Titiev

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Ever since 1884, when the Snake Dance of the Hopi Indians was first described in detail, attention has centered on that portion of the ritual during which some of the performers carry live snakes, including dangerous rattlers, dangling from their lips. In reality, the so-called Snake Dance is only a brief public spectacle which comes as the culmination of a nine-day esoteric ceremony. Again and again, observers have wondered why it is that venomous reptiles are so freely handled, yet rarely is a Snake dancer bitten, and never has a fatality been reported among participants in the ceremony. Many theories have been proposed to account for this phenomenon, some writers attributing the scarcity of accidents to the remarkable skill of the snake handlers; others quoting members of the Snake Society who have claimed that they are immune to harm if their characters are good; and one author referring vaguely to a medicine which may stupefy the reptiles while they are being carried in the mouths of the performers.

On the whole, there seems to be little need for postulating the use of drugs or the possession of any extraordinary or mysterious quality to account for the relative infrequency of injuries to the Snake dancers. Such unwarranted "explanations" have been completely dismissed by L.M. Klauber, curator of reptiles at the Zoological Society of San Diego, who has expressed the belief that accidents are rare partly because most rattlesnakes bite far less frequently than is commonly thought, and partly because all reptiles tend to become lethargic and docile after they have been handled in captivity for a number of days. It may well be that Hopi dancers are fairly clever snake handlers, but, in Klauber's opinion, they are bitten just about as often as would be the case among a comparable number of white men who had been trained to deal with snakes.

Participants in the Hopi "Snake Dance" handle with impunity several varieties of reptiles, including Prairie Rattlesnakes, the bites of which may have very serious consequences. Nevertheless, dancers are rarely stricken and never fatally injured.

Since 1884, when the "Snake Dance" of the Hopi Indians was first described in detail, attention has centered on that portion of the ritual during which some of the performers carry live snakes, including dangerous rattlers.

If it be granted that native performers are actually stricken by venomous reptiles from time to time, as our records reveal, how does it happen that they seldom show ill effects and apparently never suffer death? For example, J.W. Fewkes tells of a dancer who was bitten, presumably by a rattler. Yet, his "wound was not fatal, nor did his hand swell up, as ordinarily happens a few hours after such a mishap." To this question the conventional answer has been that the Indians possess a secret medicine that serves as a potent immunizer or antidote. However, when tested in the laboratory, the Hopi remedy has failed to show any efficacy. This was established by Dr. George E. Coleman, who once managed to secure about a pint of the reputed Hopi antidote with which he conducted experiments on a number of guinea pigs. Unfortunately, the liquid was no longer fresh at the time that the tests were made, but under the prevailing conditions, Dr. Coleman concluded that "the antidote certainly does not neutralize the venom in vitro."

Since there is no indication that the Hopi medicine possesses any therapeutic value, we must seek some other explanation for the lack of serious consequences when snake men are bitten by venomous reptiles. This brings us to the crux of our problem: Are the poisonous snakes defanged or "milked" of their venom at some time prior to the public portions of the ceremony? These points have been widely debated, and a review of the literature pertaining to the Snake Dance clearly reveals that the great majority of authors favor the proposition that the reptiles are not rendered innocuous by either of these methods. This attitude was first expressed in 1884

[1] Originally published in *The Scientific Monthly* 57: 44–51 (July 1943).

Editor's comments

Snakes have long fascinated the general public, and the combination of snakes and religion appears especially fascinating, as the all-too-frequent TV "exposes" of snake-handling Christian sects or the endless fascination with Indian snake-charmers show. This is yet another example of this obsession, but it helps illustrate several important points. First and foremost, science is a self-correcting system. The words of famous scientists, such as rattlesnake expert Laurence M. Klauber, carry much weight — but will be overturned by actual data. True scientists will admit that they were wrong, as Klauber did in this case. Not only are scientists not perfect, they are also not immune from *wanting to believe*. Possibly, some of those who concluded that the ceremonies used "hot" snakes were guilty of this. Another possibility exists, however, and this is my final point. We have a tendency to want things to be either/or. Either the ceremonies were all true, or they were all fake. The author certainly falls in that category, but life often does not. Early snake charmers in India reportedly used intact snakes, but later ones moved to safer practices that required much less training. Possibly, some of the ceremonies recorded in the early literature involved un-modified snakes, leading trained experts of the time to conclude that they were legitimate, but practices might have shifted later. Most likely, we will never know.

Gad Perry

when Bourke wrote, "Let it not be imagined that these snakes were harmless, that their fangs had been extracted, … we were all convinced that they had been subject to no treatment whatever." Nearly twenty years later, Dr. Dorsey took a similar stand. "This much may be said with confidence," he wrote, "there is absolutely no attempt on the part of the Hopi to extricate the fangs or in any other way whatsoever to render the snakes harmless." Still another writer, one never given to understatement where the American Indians are concerned, waxes almost hysterical at the accusation that the Snake Dance is a fake because the reptiles have been made safe. "Any one who knows anything about rattlesnakes," he maintains, "knows that they can not be rendered harmless except by killing them. For the snake dance, their fangs are not extracted ... the snakes are certainly not rendered innocuous."

Such has been the prevailing opinion until recent times. While it is true that none of the authors quoted above had actually examined any of the reptiles carried in the dance, their conclusions have occasionally been given weight by the observations of trained herpetologists. At the Walpi performance of 1883, for example, an army doctor named H.C. Yarrow entered the snake kiva just before the public dance, selected a large rattler at random, and "upon prying its mouth open, he found the fangs intact and of large size." Furthermore, at the conclusion of this same ceremony, two rattlesnakes were captured and sent to the National Museum where Dr. S.W. Mitchell reported that "Their fangs had not been disturbed."

The view that the reptiles are not defanged received additional support from Klauber after he had witnessed the Snake Dance at Mishongnovi in 1931. During this performance, Klauber and his son independently noted two rattlesnakes (*Crotalus confluentus confluentus* [= *C. viridis*]) that revealed their fang sheaths when their mouths were open, an indication that the fangs had neither been removed nor cut short. On the basis of these personal observations, coupled with a thorough examination of the publications pertaining to the subject, Klauber concluded that "the case for the non-disturbance of the fangs is proven."

Nevertheless, in the light of a mass of recent data, it is no longer possible to regard the issue as closed; for it can now be demonstrated that the Hopi do, at least on some occasions, defang their snakes. The first writer to uphold this viewpoint was E.S. Curtis, who expressed considerable surprise at the lack of skepticism shown by many students of the Hopi, and who quoted an experienced snake performer to the effect that the rattlesnakes are "rendered absolutely harmless by the removal of their fangs." During the course of a field trip to the Hopi in the summer of 1932, I encountered my first bit of evidence in support of Curtis' position. Together with other members of the party of which I was a member, I was present at Oraibi when an elderly native, formerly enrolled in the Snake Society, voluntarily began to deprecate the ceremony because it failed to bring rain and because the snakes were defanged. In pantomime, the speaker showed us how a snake's open mouth was rubbed up and down against something that protruded upward from the ground. At the time very little attention was paid to the old man's remarks because he spoke so little English that we could not be absolutely certain of his meaning, and because he had long been a convert to Christianity and there was a possibility that he was seeking to discredit his former religion.

Several years later, this little episode took on an added significance when two similar reports of defanging were brought to the writer's attention from other sources. Once again the information came from Christian Hopi, who, having abandoned their native faith, were now seeking to malign it. However, both men were giving their testimony to an official of the Office of Indian Affairs, and inasmuch as some of their evidence has since been corroborated by an unimpeachable investigator, it may well be that there are elements of truth in their depositions. One witness explained that he had been greatly frightened when he was ordered to catch the first snake during his novitiate, but that the snake chief had later revealed "that they had extracted the snake's fangs, teeth and poison sacs before calling him up to bag it." The speaker then went on to say that the operation was secretly performed with a hoe-like instrument, and that the poisonous snakes were examined prior to the dance to make sure that their fangs had not grown back.

A second witness, testifying in the same vein, gave additional details. According to his story, when he was a novice an experienced snake man named Satsiki had instructed him "to place his snake stick with the butt end in the ground, and the flat end in the air." Satsiki then seized the snake just back of the head, squeezed its jaws, to force them open, and rubbed the jaws along the flat side

of Deponent's snake stick, thus breaking out the snake's fangs and teeth, and squeezing out the poison sacs. He then told Deponent: "This is the way we treat the snakes, so as not to be bitten." Later on in his testimony, this witness also claimed that the snakes are examined before the dance and are again defanged if necessary.

Such statements by renegades from their native religion might well be dismissed as biased and untrustworthy were it not for the fact that they have recently received striking confirmation in at least one instance. At the close of the Chimopovy Snake Dance on August 24, 1932, C.M. Bogert, now assistant curator of herpetology at the American Museum of Natural History, followed one of the performers and watched him liberate his quota of reptiles at a shrine. As soon as possible after the dancer had withdrawn, Bogert hurried to the spot and succeeded in capturing a single rattler which had not yet escaped into the open. His published account of this adventure is directly pertinent to our discussion:

"In the sanctum of a gully not far from the shrine, a stop was made to examine the rattlesnake in case anything were to happen which might not later allow us the opportunity to do so. From Klauber's observations, and from the accounts of most ethnologists ... I fully expected to find the venom apparatus intact. Therefore, it was something of a surprise, upon prying the snake's mouth open with a pencil, to find the fangs entirely lacking and obviously removed. With the object of learning something regarding the condition of the venom glands, pressure was applied with the thumb and finger to the proper region, but no venom, at least none recognizable as such, was forced into the mouth. Of course, with the fangs removed, it would be difficult to observe and identify a discharge of venom."

In order to have his own examination made in the field confirmed, Dr. Bogert later sent the snake to Klauber. Under date of September 16, 1932, Klauber sent a letter to Bogert which reads in part: "I pickled the snake last night and found as you had supposed that apparently not only the functional fangs had been removed, but all of the rudimentary fangs as well. In fact, it would appear that the sockets in the maxillary, which normally hold the functional fangs, were completely extirpated. This has been done with a knife as indicated by cuts rather than tears, and on the whole it was rather well done, if you forget the snake's feelings in the matter." Thus, within a period of nine months after he had concluded that "the case for the non-disturbance of the fangs is proven," did Klauber cheerfully admit that the opposite was undoubtedly true in at least one instance.

Before the dance begins, dancers take an emetic (probably a sedative herb or hallucinogenic) and then dance with the snakes in their mouths.

Of course, as Bogert is careful to point out, the discovery of a single defanged rattler does not imply that all the dangerous reptiles are defanged; nor must we forget that Yarrow and Mitchell had found rattlesnakes which had not been operated upon. In the latter instance, however, there is still the possibility that the Indians had resorted to the simpler method of rendering the snakes harmless by "milking" them of their poison. It is significant that even at the time when Klauber was convinced that the Hopi did not defang their snakes, he had indulged in an interesting bit of conjecture on this score. "To my mind," he wrote, "the removal of the venom ... would be so easy and safe, and so much more difficult to detect, that this is a more plausible explanation of how the Indians handle the snakes so fearlessly and with so few adverse effects." He then goes on to state that the removal could readily be accomplished by letting the reptiles strike at some soft object, or by manipulating their venom glands.

This hypothesis finds support not only in the testimony of the Christianized natives cited above, but also in the words of a faithful Hopi. In an interview with Stephen in 1885, Wiki, an orthodox Hopi official, who had long served as Antelope chief of Walpi, remarked, "The snake whip is used to cause the snake to strike at it repeatedly and exhaust the venom. As soon as the venom sac is empty the snake straightens out, and he is then seized." Thanks to Wiki's authoritative testimony, it is plainly evident that even if the Hopi do not invariably defang dangerous reptiles, they may still render them harmless by a "milking" process.

Armed with the knowledge that the Hopi do, at least occasionally, take pains to make their snakes safe, we may now venture to read somewhat between the lines in a few of the earlier publications, in order to point out the strong probability that the members of the Snake Society have long conspired to hide their treatment of snakes from white observers as well as from their fellow tribesmen. To begin with, it should be explained that whereas the Hopi have sometimes permitted spectators to watch nearly the entire schedule of rites, they have usually managed to secure privacy just before the public dance begins, and on the occasion of snake hunts. For example, Bourke reports that he and his companions were allowed ready access to the snake kiva at Walpi in 1881, but just as the public exhibition was about to begin one of the old men persuaded them to leave lest their clothing be stained by the paint which the dancers were applying to their bodies. To anyone who has ever lived in a Hopi pueblo the old man's ruse is perfectly clear, for the one thing to which elderly Hopi are most completely indifferent is dirt of any description!

Even more revealing are the subterfuges employed to keep spectators from witnessing the snake hunts. Uninitiated tribesmen are kept away by a stock device of Hopi ceremonialism. They are warned that those who trespass on the hunting grounds will either be stricken with fatal swellings (a disease supposedly controlled by the snake cult), or else they will be forced to join the Snake Society, a contingency which is dreaded by the average Hopi. As for white men, either they are simply requested not to come into the neighborhood of a snake hunt, or else they are told that the presence of strangers will interfere with the success of the searchers. The language in which Stephen was forbidden to join a party of hunters is

particularly significant. "They say it will be bad for the young snake members who are to catch their first snakes today," he comments. It is only when we recall the vivid testimony of the Christian deponents (vide supra) that we can fully appreciate why the presence of a white man would have been "bad" for the novices.

Perhaps the strongest "between-the-lines" testimony of all is to be found in the Reverend H.R. Voth's account of an incident that occurred at Oraibi in 1896. When it was learned that Voth was bent on joining a hunting party, the older snake men became greatly upset. At first they merely insisted that his presence would make the search unsuccessful; then they literally begged him not to go along; and finally they offered to strike a bargain with him. As Voth relates their terms, "I could see and hear everything else, only I should do them the favor and not go with them on the snake hunt"; and when Voth agreed to these conditions, "a big burden seemed to have rolled from their hearts."

On a different occasion, however, Mr. Voth did actually accompany a group of hunters from Oraibi. Unfortunately, he was afraid that he would not be able to keep up with the more vigorous searchers, so he elected to follow the old snake chief who was "entirely blind in one eye, the other one being very poor," and another man who was also "old and feeble, and also nearly blind." Needless to say, Voth saw no snakes captured, and we may imagine the laughter of the younger snake men at the prospect of Voth's endeavor to discover their secrets by following a pair of feeble, dim-sighted old men.

By one means or another the Hopi Indians have generally succeeded in preventing outsiders from watching their snake hunts at close range. Only Stephen has published an eye-witness account, but it is evident from his report that the snake which he saw taken had first been found by a distant hunter who had then called the rest of the party to him. Had this man so desired, he could have operated on the creature before summoning the others to watch its capture — a trick which experienced Snake men apparently play on novices.

In one instance Dr. Fewkes showed Kopeli, head chief of the Walpi Snake Society, a hole in which he had noticed a rattlesnake, but Kopeli flatly refused to dig it out in his presence. Fewkes attributed Kopeli's refusal to the great care with which he was trying to "preserve this one feature of the ceremony, the capture of the reptile in the open"; but somewhat naively, Fewkes overlooked the possibility that Kopeli might actually have been afraid of a genuinely dangerous rattler. In support of the more realistic interpretation of this episode, we have Voth's explicit statement that "At any other time except during the ceremonial days, the members of the Antelope and Snake Fraternity seem to be just as much afraid of a rattlesnake as other people." On a number of occasions, Voth challenged snake men to pick up rattlers which he had discovered, but this "they very emphatically refused to do, saying that if they ... touched a snake while they were not 'assembled' they were just as liable to be bitten as any other person."

An Antelope Priest may help with the dance, sometimes stroking snakes with a feather or supporting their weight.

As for the Antelope men, their fear of untreated rattlers may be so great as to border on the ludicrous. In one case Voth dared a friend of his, an Antelope Society member, to pick up a rattlesnake. When he refused, Voth struck the snake a blow, picked it up and began to pursue his friend who "dashed away and screamed, evidently in genuine fear, crawled ... under a wire fence, and ran away as fast as his legs would carry him." It might be argued, of course, that the person whom Voth had so badly frightened was an Antelope man, and as such he may not have had the skill in handling reptiles that the snake men learn to acquire; yet, had this same individual been handed a rattlesnake by one of the gatherers at the public spectacle, he would have held it with apparent nonchalance as he sang and rattled in the fashion prescribed for his group.

Summary and Conclusion

In the course of the Hopi Snake Dance the participants handle with impunity several varieties of reptiles including the prairie rattlesnake, whose bite may have very serious consequences. Nevertheless, dancers are rarely stricken and never fatally injured. This immunity results neither from the use of stupefying drugs nor from the employment of therapeutic immunizers or antidotes. Instead, the safety of the performers is achieved partly by making the snakes docile through careful handling in captivity, and partly by resorting to such devices as defanging and emptying the venom glands. Although the latter practices have been frequently denied by former writers, a review of all the evidence available clearly points to the conclusion that the Hopi can, and occasionally do perform such operations; perhaps with the metal-tipped digging sticks and feather "whips" which are part of the Snake Society's equipment.

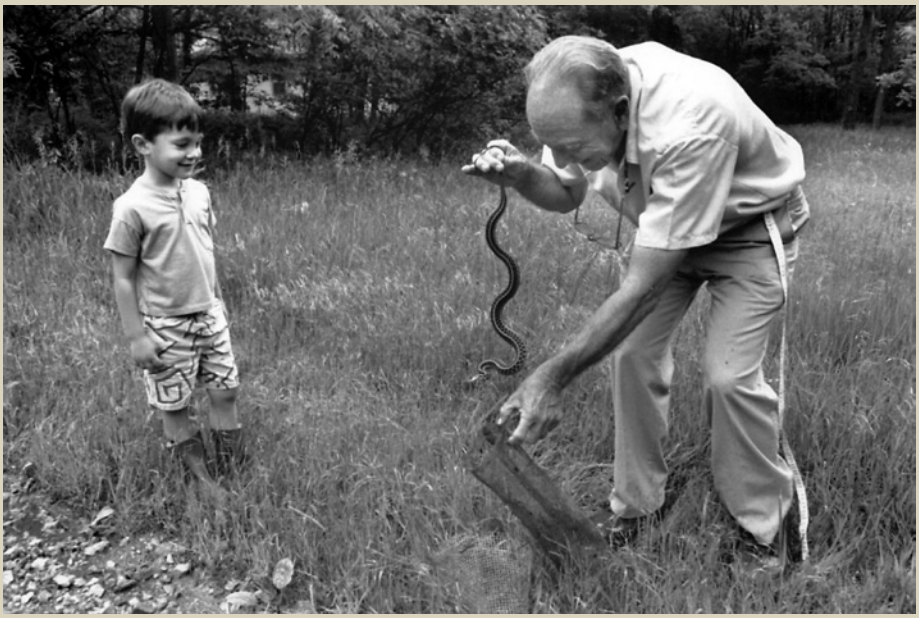
It would be unwarranted, in the present state of our knowledge, to claim that all the rattlesnakes used in the ceremony are made harmless; but on the other hand, it can no longer be maintained that the snakes are never treated or that the Hopi dancers are recklessly indifferent to the dangers of venomous snake bites. In all likelihood, future researches will reveal that the major operations are performed systematically, according to some pattern of ritual procedure that has not yet been discovered. Indeed, it is already reasonably certain that the greatest care is exercised to render rattlers innocuous on those occasions, like snake hunts, when novices are about to handle them for the first time. In my opinion, this is done both to protect the tyros from harm, and to inspire them with the necessary confidence so that they may perform in public with that air of calm indifference to great danger which makes the snake dancer a hero to his own people, and an object of awe and admiration in the eyes of white spectators.

TRIBUTE

Henry S. Fitch
1909–2009
"The father of snake ecology."

His keen eye and perseverance, his many years of dedication to field research, deep understanding and appreciation of his subjects, and timeless contributions will continue to inspire those of us who study reptiles and amphibians for many, many years to come.

As a tribute to Henry Fitch, the IRCF and editors of *Reptiles & Amphibians* are dedicating the March 2010 issue to his memory and impact on natural history and the entire herpetological community.



Henry Fitch and friends in 1991.

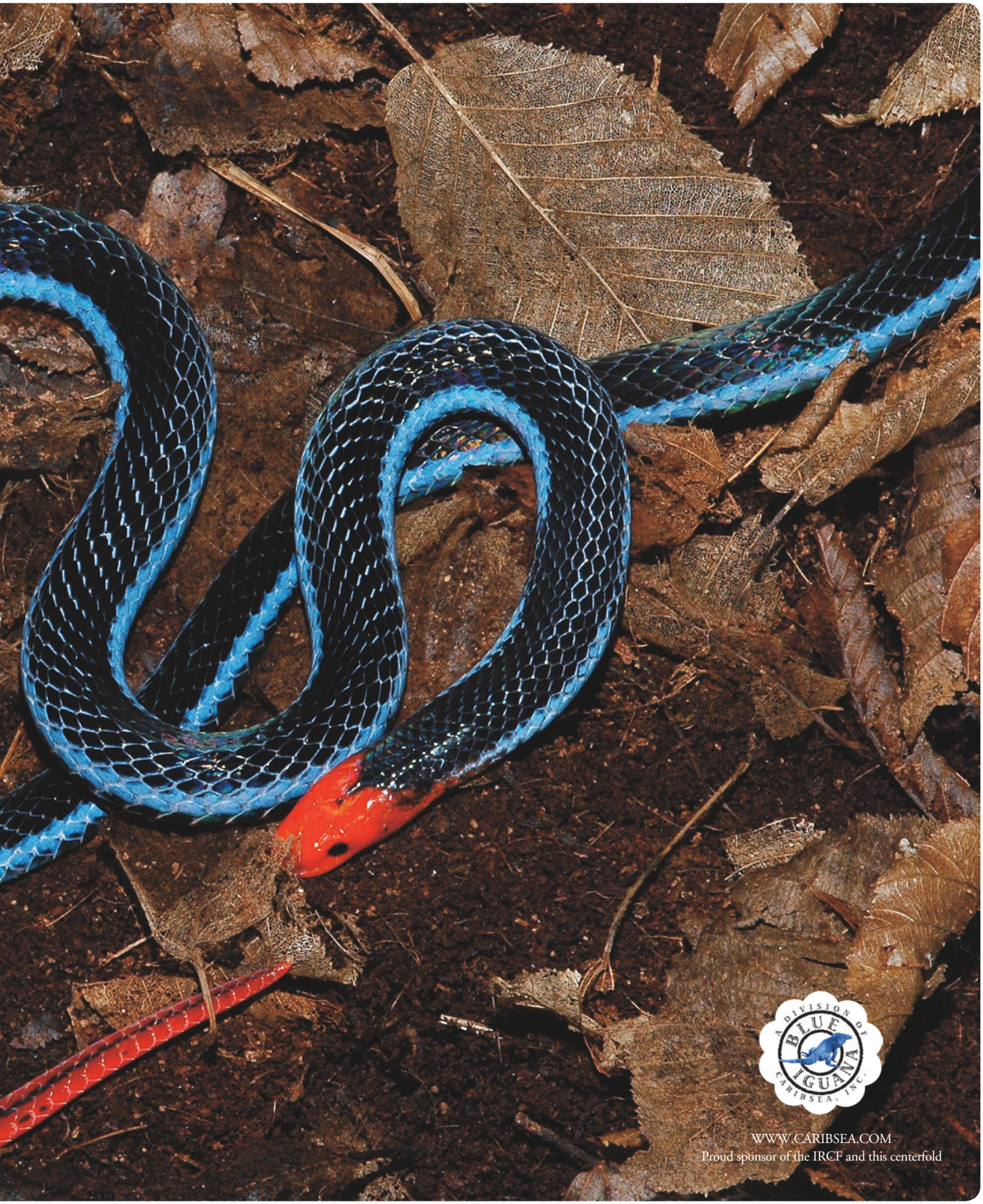
"In the last few weeks, many have written remembrances of Henry Fitch. In reading through some of these, I have noted a consensus in describing the qualities of this man:

- Quiet and reserved — a man of few words but wide knowledge;
- Energetic and enthusiastic about field studies and natural history — almost universal mention of the difficulty younger students had in keeping up with the old man in the field;
- Gracious, gentle, and kind — the gentle encourager of students and patient explainer to children and adults — and yet he had high standards of excellence;
- Parsimonious — completing field studies with a minimum of expense;
- Modest and unassuming — not fighting to create his own "academic empire" — **but** very competitive in basketball;
- A stubborn confidence and determination, and I would add perseverance, and focus to learn as much as he could about the life on [the] one square mile [of what is now known at the Fitch Natural History Reservation at the University of Kansas]."

Dwight R. Platt
"A Tribute to Henry Sheldon Fitch: A Legend in Our Time"
Annual Meeting of the Kansas Herpetological Society, 7 November 2009

MAIK DOBIEY (HTTP://MAIKDOBIEY.COM)

Blue Coral Snakes (*Calliophis bivirgatus flaviceps*) live in wooded hills and lower montane
If molested or threatened, they roll their tails and expose the red underside. Although generally p



regions in southern Thailand. These snakes are usually nocturnal. They move very slowly.
eaceful and not inclined to bite, the venom is very potent and human deaths have been recorded.

ROSTISLAV STACH

Lesser Antillean Iguanas (*Iguana delicatissima*) are the subject of new educational signs provided by the IRCF for use on St. Eustatius. This adult was photographed at the National Parks Visitor Center.

CONSERVATION ALERT

New Iguana Signs and T-shirts Raise Awareness on Statia

Nicole Esteban, Manager

St. Eustatius National Parks

Photographs by the author except where indicated.

In April 2009, the St. Eustatius National Parks Foundation (STENAPA) received a generous gift from the International Reptile Conservation Foundation (IRCF), an organization that has supported the Foundation's conservation and education efforts in the past. In 2005, the IRCF was responsible for a set of signs featuring the conservation status of Statia's iguanas. Those were erected around the island, but had become faded due to exposure to sun and rain. The IRCF kindly offered to replace them.

Fundraising efforts by IRCF members in the United States managed to raise sufficient funds to not only replace the signs, but to improve on their quality. Additionally, the IRCF sent T-shirts that were presented to the Commissioner for Environment, all five Tourism Office staff, the nine members of the STENAPA board, and eight staff members. The Nustar Statia Oil Terminal provided

Signs have been placed strategically all over the island; this one is near the Lynch Plantation School.

A new sign at the entrance to Dutch Plumbing Services in the business district.

VICTORIA H. ZERO

This iguana (indicated by the circle) seems to be seeking protection from the old sign that had been posted on the lower slopes of the Smoke Alley cliffs. The old signs had faded with exposure to sun and rain. Whether the iguanas approve of the new signs remains to be seen.

shipping for the signs that gently remind the general public, residents and visitor alike, that our Lesser Antillean Iguanas (*Iguana delicatissima*) have disappeared from many nearby islands and are protected by law on Statia.

The signs have definitely increased awareness about the endangered status of our iguanas. Residents now phone the STENAPA office to alert staff of iguanas messing up their yards, in response to which the offending iguanas are relocated to a safer location. In the past, many individuals would have simply killed and eaten them. Also, increasing evidence speaks to the growth of the iguana population. Five iguanas (juveniles through mature males and females) occupy the yard at the National Park Visitor Centre, and reports suggest that numbers are growing elsewhere on the island as well.

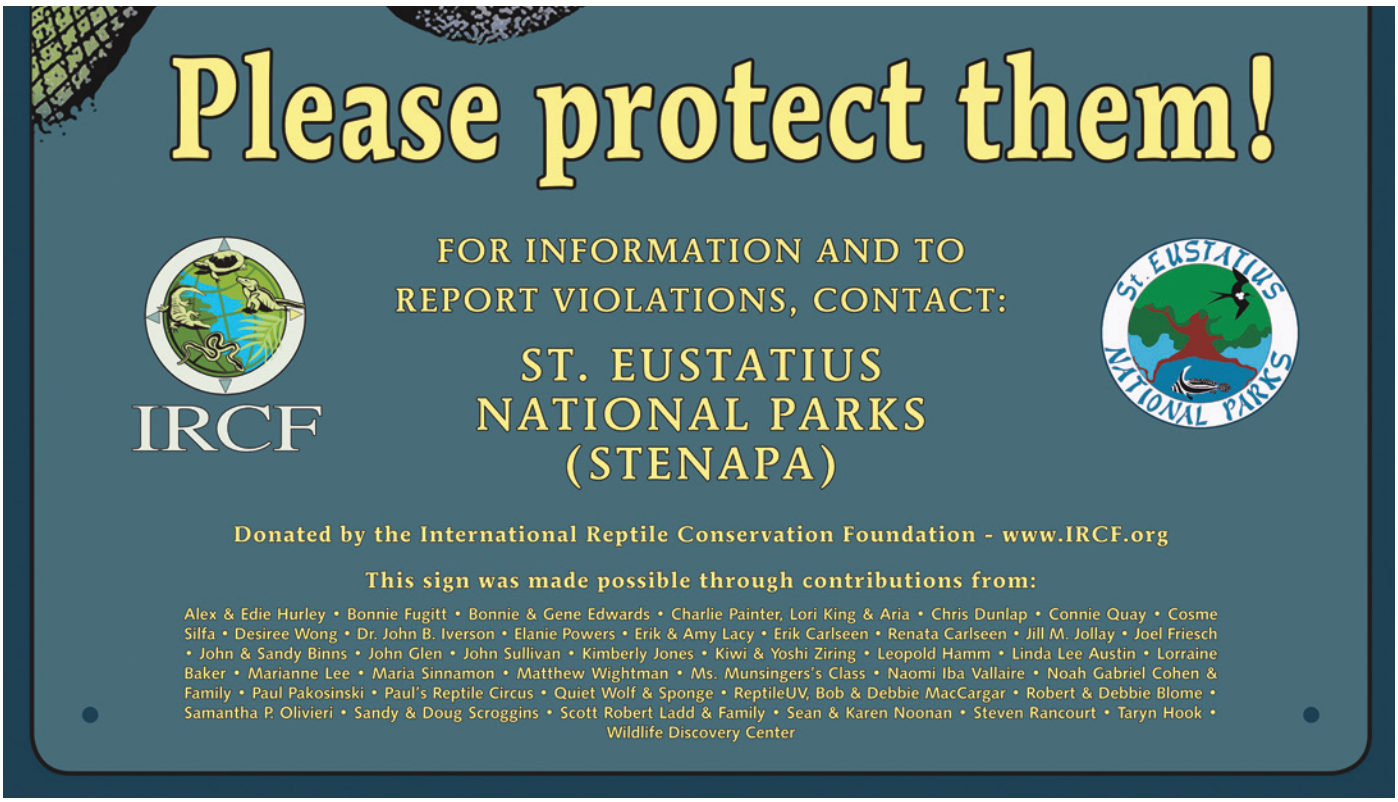
Iguana T-shirts are a big hit and have elicited many positive comments. Here, Nadio Spanner and Carlton van Putten of the STENAPA staff show off their new shirts.

MICHELE FAIRES

STENAPA staff sporting their new t-shirts in front of the National Parks Foundation office (from left: Nicole Esteban, Violet Busby, Hannah Madden, Jessica Berkel, Tadzio Bervoets, and Walter Blair).

Chloe and Leon Esteban with one of the new signs at the entrance to the Quill National Park.

Another one of the new iguana signs at the entrance of the Miriam C. Schmidt Botanical Garden.



The new signs list the names of donors who contributed funds.

P. ULMER

Darwin's Frog was formally described by Gabriel Bibron and André Marie Constant Dumèril, who described a number of species from Darwin's collection. Among these, in 1841, was a very special frog that the French researchers named in honor of its discoverer: *Rhinoderma darwinii*.

From Darwin's Treasure Chest: *Rhinoderma*

Heiko Werning

Redaktion *REPTILIA*, Berlin, Germany (redaktion-reptilia@ms-verlag.de)
Translated from German by AJ Gutman

In 1831, as Charles Darwin began his five-year voyage around the world aboard the HMS *Beagle*, he could hardly have imagined that the impressions he was about to collect would profoundly and permanently change the world. Compared to the later influence of his evolutionary theory, Darwin's other talents, as a natural scientist with universal interests, as a best-selling author of travelogues and natural history reports, and as a collector who dispatched and brought back to Europe a wealth of material, are easily overlooked. Herpetology also benefited from his discoveries. Among Darwin's collections were countless species previously unknown to science. Evaluation of this material was entrusted to Thomas Bell, a task he found somewhat overtaxing. Thus a portion of the work was passed on to the Natural History Museum of Paris, where Bell's friend Gabriel Bibron, along with colleague André Marie Constant Dumèril, described a number of species from Darwin's collection. Among these, in 1841, was a very special frog that the French researchers named in honor of its discoverer: *Rhinoderma darwinii*.

Charles Darwin shortly after returning from his voyage on the H.M.S. Beagle.

Darwin's Frogs

In February 1835, the *Beagle* anchored in Valdivia, Chile. There, in the temperate rainforest, Darwin discovered some remarkable little frogs. Particularly impressed by these little mites, he recorded atypically detailed observations in his zoological notes. Among other things, he noted their variety of colors and their unusual appearance ("very pretty & curious").

Darwin's original observations on what was to become known as *Rhinoderma darwinii* included the following paraphrased descriptions of several specimens:

> Under side [of] throat, breast & cheeks rich chestnut brown, with snow-white marks; thighs of hind legs blackish with no marks. Legs yellowish also with no marks.— Upper side, pale iron-rust color, with posterior parts of body, thighs & anterior marks (one triangular & other transverse) beautiful bright green.— Iris rust color. Pupil black.— Eyes small.— Appearance very pretty & curious.— Nose finely pointed.— Jumps like a frog. Inhabits thick & gloomy forest. Is[d] of Lemuy.

> This species is excessively common in the forest of Valdivia. Seems subject in its colors to remarkable variation.— Undersurface posteriorly jet black & snow white marks, anteriorly rich chestnut brown; above cream color, with triangular slightly darker shades & small marks of green.— There is a point in all at joint of hind legs.— Iris of all is rusty red.

> Above cream-colored, without shade of green. Hind legs yellow; beneath all black with different shaped marks of white.

> Another, beneath anteriorly the brown is replaced by bright yellow.— Upper surface instead of cream color, rusty red — with darker triangular shading.— All die soon in confinement.

The unusual nature of these frogs did not become evident until much later. The genus *Rhinoderma*, as currently recognized, comprises two species: Darwin's Frog (*R. darwinii*) and the more northerly distributed *R. rufum*. Conventional systematics views these two species as the only representatives of the family Rhinodermatidae, although Frost et al. (2006) no longer recognized this family, instead placing *Rhinoderma* in the family Cycloramphidae.

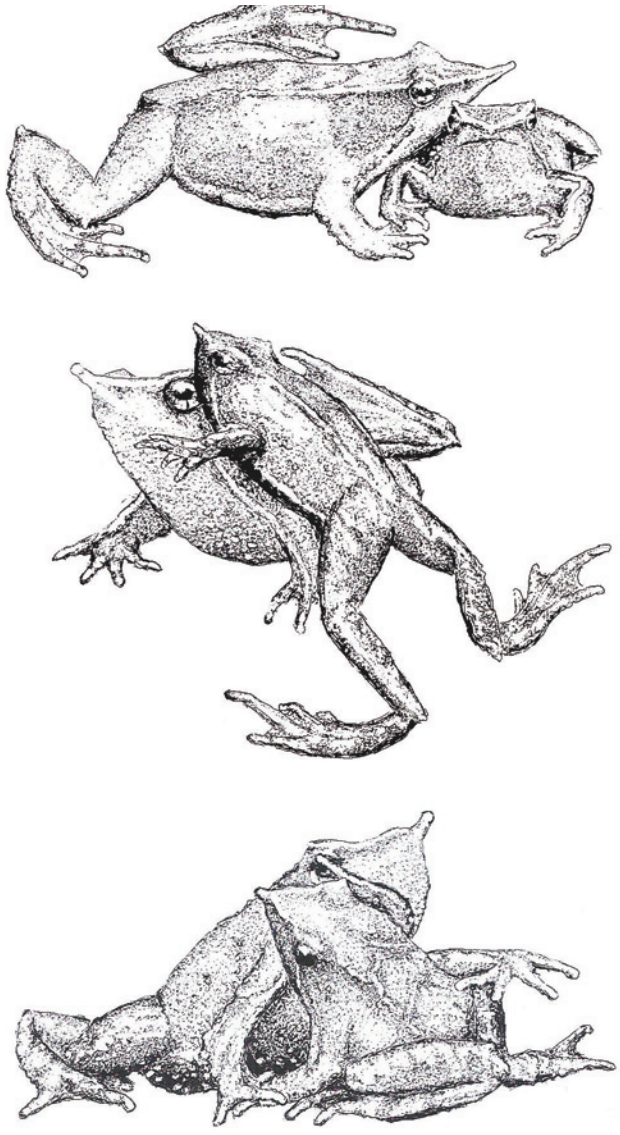
Darwin's Frog reaches 3–5 cm in length. Notable are the various and highly variable skin flaps, including the nasal protrusion for which the genus is named. These structures generally are interpreted to mimic leaves, allowing the frog to blend effectively with the plants and organic debris of its leaf litter habitat. Camouflage is further enhanced by the species' variable color, which ranges from the brown of dried leaves to the bright green of new growth. The ventral side is marbled black and white and is highly variable from


H. WERNING

The Valdivian forests of southern Chile are home to Darwin's Frogs.


H. WERNING

The natural habitat of *Rhinoderma darwinii* in the Araucarian forests in Southern Chile.



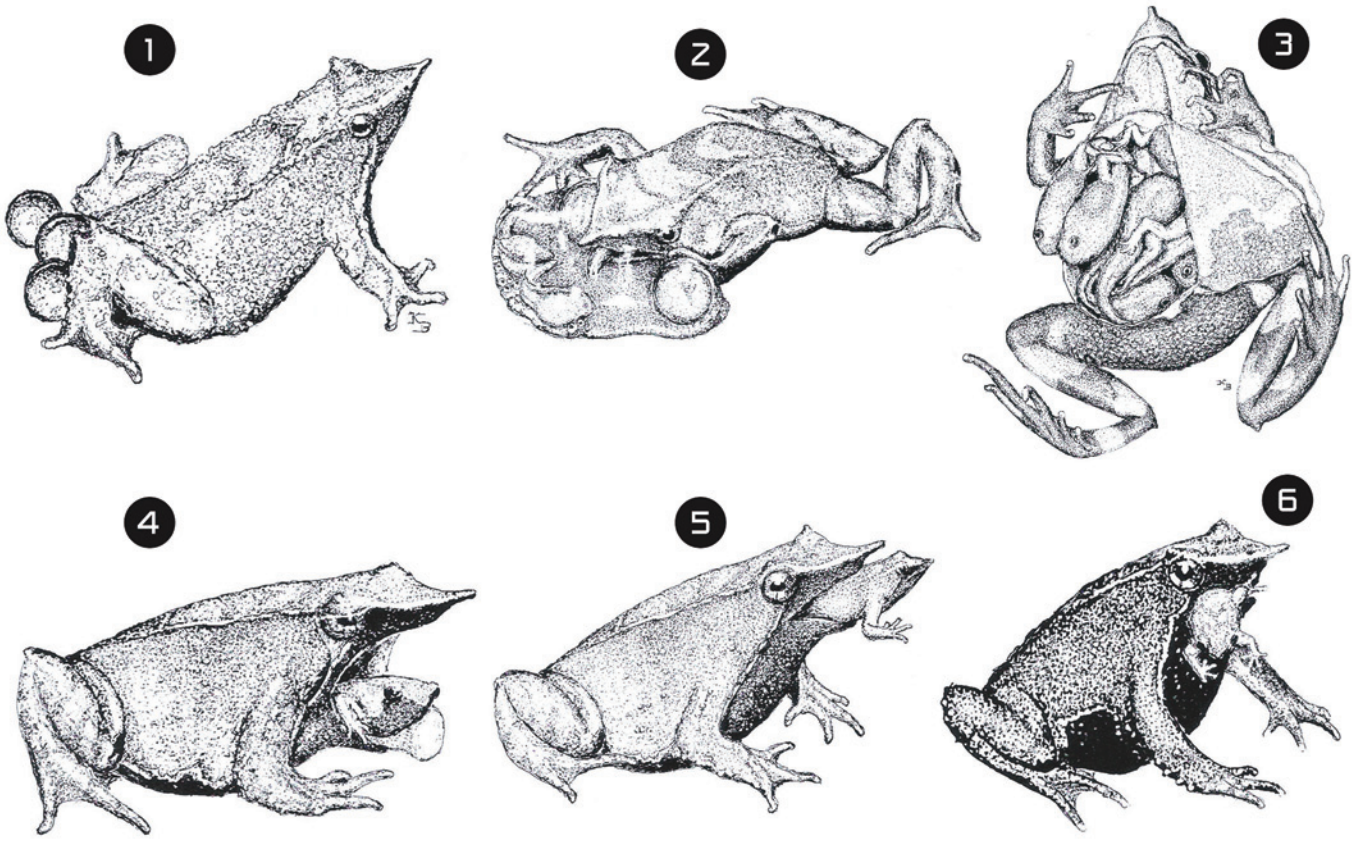
Mating behavior can extend for extensive periods. (1) The larger female approaches a male immediately after chasing another male away, (2) responds to the male's embrace, and (3) reciprocates in kind. Drawings by K. Busse from a videotaped encounter.

one frog to another, so much so that individuals can be uniquely identified by their ventral pattern.

Darwin's Frogs inhabit the Valdivian rainforest in southern Chile and adjacent regions of Argentina. The species' distribution extends from around the level of the Chilean city of Concepción into northern Aysén Province. The extent of its southern distribution is unknown. This area is characterized by temperate rainforests. The average summer temperature is ~15 °C (Puerto Montt) and precipitation is ~2,000–3,000 mm/year, but may exceed 5,000 mm/year in some regions. Rain falls throughout the year, with a record at one locality of 360 rainy days in one year. Characteristic tree species include *Araucaria*, Southern Beech (*Nothofagus*), and Alerce (Patagonian Cypress, *Fitzroya* — named after the captain of the Beagle). Within the forest, frogs are diurnally active and generally inhabit more open areas with heavy ground cover.

Reproductive Biology

Darwin's Frogs are notable for their unusual reproductive biology. Males employ a singular means of oral incubation in which the hatching tadpoles are collected in the vocal pouch, where they remain until metamorphosis. The newly metamorphosed froglets are then expelled. Mouthbrooding is unique among amphibians and has been known since the latter half of the 19th Century. However, many interesting details of this reproductive behavior have been described only recently from two decades of observa-



ANTHONY LAU

Mating behavior continues with ovideposition. (1) The pair was disturbed and the male had just jumped away. (2) The male "swallows" the hatching tadpoles in the eggmass. (3) Male with tadpoles in his vocal sac (diagrammatic). (4) Male "spitting out" the metamorphs. Expulsion is triggered by contractions of the lower body combined with gaping. (5) A metamorph emerges, only to be caught by the male's closing mouth. (6) The male holds the froglet by a hindlimb just before final release. Drawings by K. Busse from a videotaped encounter.

tion and research of captive specimens by Klaus Busse (2002) at the Koenig Museum in Bonn, Germany.

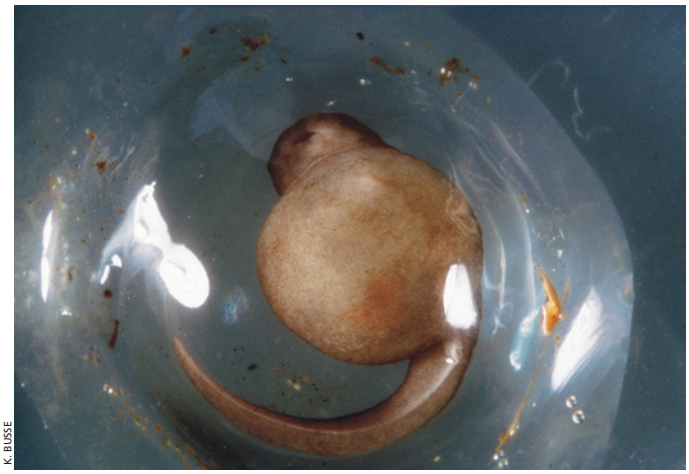
Males call (a bird-like sequence of 3–5 whistling tones) from in or in front of a retreat during the damp, cool weather from spring until at least late summer. When a female is ready to spawn, she will approach, using the calls to navigate what for them is dense, visually impenetrable terrain. Once the two have found each other, the female often will react with a rather impertinent gesture, hurling the male away from her with a powerful kick of her hind legs. Hardly deterred, the male approaches again. Busse hypothesized that this "jumping-onto-kick-off behavior" serves a useful purpose. Since the male is exclusively responsible for raising the larvae, simply fertilizing her eggs is insufficient. Instead, she is seeking to enhance the likelihood of her progeny's survival by identifying the strongest possible male, one who is capable of the demanding task ahead, both genetically and physically. To put it simply, the farther the male flies when he's kicked, the punier and less suitable he is for raising her tadpoles. This highly unusual method of assessing suitability for fatherhood seems to be exclusive to Darwin's Frogs.

P. ULMER

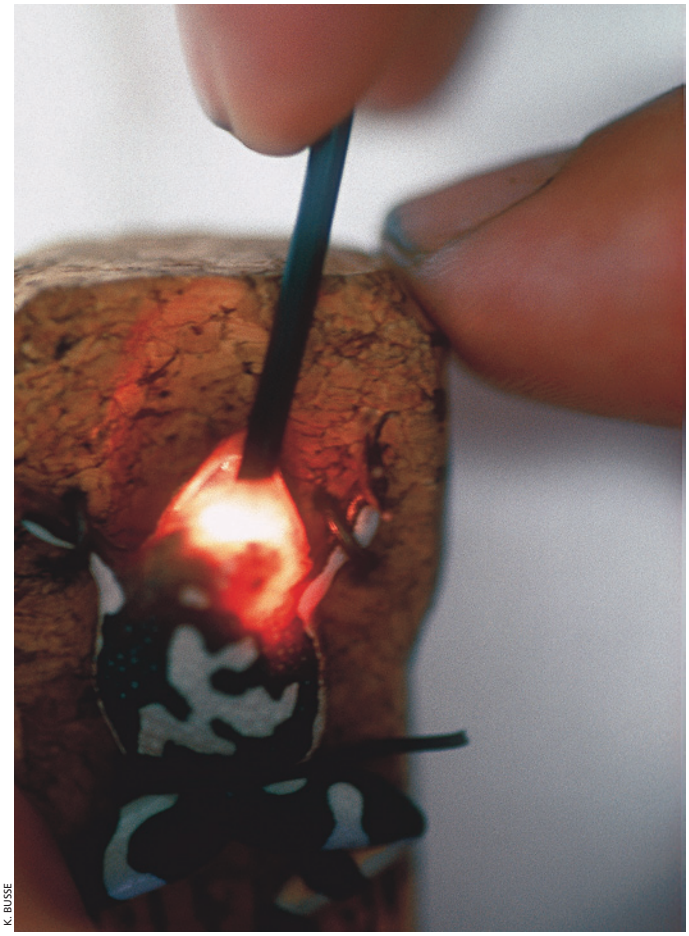
More gut than frog: A male with vocal sacs filled with tadpoles.

Once, however, the female is satisfied with his flight characteristics and potential for caregiving, she will follow the male into a small, damp depression in the soil or leaf litter. There, after extensive mutual stimulation, including continuous calling, mutual embracing, and caressing, oviposition and fertilization take place. Due to the high ambient humidity, the eggs and larvae do not require open water. Eventually, both parents withdraw. Males do not guard the egg clutch, which develops for about 20 days.

Just as the egg membranes dissolve and the tadpoles hatch, the male returns. Since the time interval until hatching can be quite variable depending, for example, upon temperature, the punctual


K. BUSSE

Tadpole in the egg a few days before hatching and being relocated into the male's vocal sac.


K. BUSSE

"Candling" the vocal sac of a "pregnant" male reveals the tadpoles contained within.

arrival of the father is amazing, particularly in the apparent absence of any obvious regulating factors. The hatching tadpoles might summon the male by sending some kind of chemical signal, but we do not know for sure what triggers his response.

Similar to many other species of frogs, the tadpoles are dark on the back and lighter on the underside, although any protection provided by this countershading (a protective coloration usually associated with purely aquatic animals) obviously does not apply here. Instead, the larvae thrash about vigorously, and the constant light-dark color change seems to produce a flashing signal that motivates the male. He picks up each individual tadpole with his mouth and they slide down into his vocal pouch where they continue to develop for 1–2 months (depending on environmental conditions). Nutrition of the tadpoles has yet to be clarified, although they likely are dependant on the unusually large yolk sacks that they retain after hatching. In addition, the inner epithelial layers of the male's


K. BUSSE

Freshly laid eggs in captivity.


K. BUSSE

Adult Darwin's Frog with metamorph.

J. BOURKE

Darwin's Frog in nature.

M. SOLÉ

M. SOLÉ

M. SOLÉ

M. SOLÉ

Darwin noted the considerable variation in color among individuals.

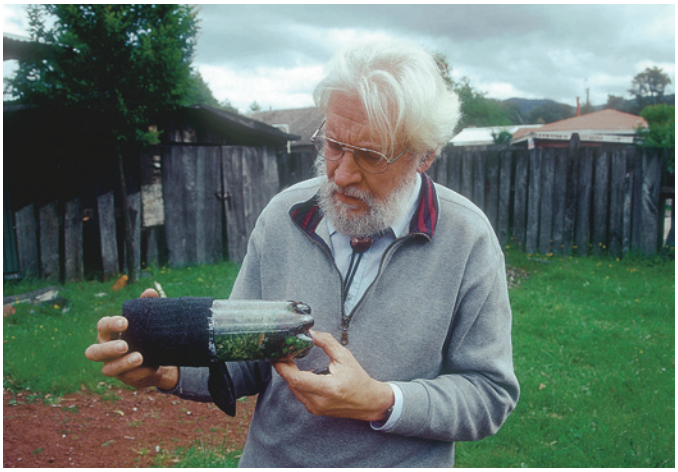
vocal pouch are believed to produce a substance that might provide additional nutrition. This substance is presumably absorbed through the skin of the larvae. Whether oral intake also takes place is unknown. In any case, this form of direct nutrition of the tadpoles through the father (patrotrophy) is so far unique among frogs. Also, the question of an oxygen supply for the larvae remains to be addressed. Busse (2002) suspected that an internal "foam nest" provides a direct oxygen supply via the circulatory system of the father. The male continues to feed during the incubation period, apparently uninfluenced by his "pregnancy."

Once the larvae have metamorphosed, the male spits out his progeny over a period lasting from minutes to hours. The young frogs, although somewhat abruptly expelled into the light of day, are nevertheless fully functional. Quickly recovering from their startling change of scenery, they hop off to lead their independent lives.

The Mysterious Second Species

Philippi (1902) described a *Rhinoderma*-like species under the name of *Heminectes rufus.* This name fell more or less into disuse, as subsequent authors regarded it as a synonym for *R. darwinii.* The two species actually are relatively easy to distinguish. Darwin's Frogs have barely any webbing on their hind feet, whereas the webbing on the hind feet of *R. rufum* is very well developed. The calls of the two species also are easily differentiated. Definitive proof of their status as separate species was provided by studies of reproductive biology during the 1970s. The webbing is a strong indicator, with *R. rufum* much more strongly tied to bodies of water than its more famous relative. The male of this species also takes the hatching tadpoles into its vocal pouch but, after a stay of about two weeks, the young are released into small streams. Consequently, the reproductive biology of *R. rufum* represents a link between the more "normal" mode of many frogs and the highly specialized brood care of *R. darwinii.*

Map showing the approximate ranges of *Rhinoderma darwinii* (green) and *R. rufum* (brown).



H. WERNING

Dr. Klaus Busse of the Alexander Koenig Museum in Bonn with a container for transporting freshly collected Darwin`s Frogs.

H. WERNING

The type locality of *Rhinoderma rufum* is now a pine "desert" (top); forest monocultures have replaced the natural habitat of the species.

The distribution of *R. rufum* lies to the north of that of *R. darwinii*, although the two species overlap in the area around Concepción. Historical type localities indicate a distribution as far as Zapallar, about 100 km north of Santiago in central Chile, a region characterized by dry, hot summers.

The habitat of *R. rufum* clearly differs from that of *R. darwinii*, with the former restricted to drier forest types within the rainforest and also occupying sclerophyllous vegetation in areas with a Mediterranean climate. In those situations, moisture adequate for reproduction is restricted to riparian zones that often are enclosed by arroyos with dramatically steep walls. Dense layers of shade-producing vegetation within the arroyos create suitable microhabitats amid the dry heat of the surrounding areas. The notably cooler and damper Mediterranean conditions allow frogs to remain active throughout the year.

An Extinct and an Endangered Species

Since the studies on its reproductive biology, *R. rufum* seems to have vanished without a trace. Because it had long been considered to be conspecific with *R. darwinii*, it had been largely ignored. Also, its occurrence in limited microhabitats (even within a large distribution range) ensured that it was unlikely ever to be found in great numbers. During a 2001 conference in Santiago de Chile, to which Klaus Busse and I had been invited as speakers, Busse reported on his many years of experience working with *R. darwinii* and expressed the wish to carry out comparative studies with *R. rufum*. The conference participants and all of the herpetologists and concerned lay people that were questioned later assured him that the species had not been seen in years — and yet, had anyone actually gone out purposefully seeking the tiny things? Consequently, we (representatives of the German edition of the magazine *Reptilia*, the Zoologische Forschungsmuseum Alexander Koenig, and the Zoological Society for the Protection of Species and Populations), in close cooperation with the Chilean Ministry of Agriculture, established a conservation and research project for these frogs. Among the most important financial supporters, aside from the many private contributors among the readers and authors of *Reptilia*, were the Amphibian Decline Task Force, the North of England Zoological Society, and the Zoos of Leipzig and Chester. We had many reasons for concern. The Valdivian Rainforest fell outside the global focus on tropical rainforests and was subject to substantial economic use and rapid destruction. Habitat for *R. darwinii* continues to shrink each year, and *R. rufum* was presumed to be extinct.

H. KREIBICH

Klaus Busse and the author in 2003 searching for *Rhinoderma rufum*.

K. BUSSE

Eighty percent of the world's combined museum collections of *Rhinoderma rufum*; the larger pile on the left is from the Zoological Institute in Hamburg and that on the right from the Alexander Koenig Museum in Bonn. Additional specimens are in Valdivia, Chile.

M. SOLÉ

A brown-mottled morph in nature.

K. BUSSE

Terraria for breeding Darwin`s Frogs at the Alexander Koenig Museum in Bonn.

We undertook an extensive search to find any extant *R. rufum*. We sought the frogs ourselves, we integrated local Chilean colleagues into our search parties, and we sent in renowned international herpetologists. We played back recordings of the species' mating calls, but they went unanswered. We thrashed through blackberry hedges and pinewood plantations; we combed through the vegetation belts, at times only a few meters wide between the streams and forests; we fished for tadpoles. We searched all of the known historical localities and every other spot that seemed suitable during our several-months-long excursions from 2003 to 2006 — all for naught. Given the size of its potential distribution area, hope remains that *R. rufum* still survives somewhere to this day. Our activities in Chile raised awareness and countless local park rangers, conservationists, and zoologists have taken up the search; nevertheless, no *R. rufum* has yet been sighted, and we are inclined to suspect the worst.

Since 2006 we have concentrated increasingly on *R. darwinii,* and we found several new populations in recent years. Many questions about this species remain to be answered. Of concern, although not yet investigated and scientifically verified, are disturbing reports from local park rangers and conservationists that the number of Darwin's Frogs have decreased in recent years. Is it possible that an entire unique and spectacular genus of frogs is becoming extinct before our very eyes?

With further financial support from the zoos in Chester and Leipzig, we have outlined a doctoral study that should help to collect important data over a five-year period on the ecology of *R. darwinii*. Chilean herpetologist Johara Bourke, with support from the universities of Bonn (Germany) and Concepción (Chile), has been working on this project since the end of 2006. This long-term study, focusing on population monitoring, is supported in large part by our project (as well as by the Deutsche Akademische Austauschdienst). Initial findings on the ecology of *R. darwinii* will be published in the near future.

A. GUTSCHE

The containers are in place, but the holding pens are still vacant.

M. SOLÉ

Color can vary from brown to green — or some combination of the two.

J. BOURKE

An informal ceremony as the research and breeding facility became functional. Prof. Juan Ortíz is on the left; third from the left is Dr. Alexander Gutsche of the Humboldt University in Berlin.

A Breeding and Research Station

Another part of the project involves the *ex situ* breeding of *R. darwinii*, initially planned at the Chester Zoo. In 2007, we imported 30 Darwin's Frogs from Chile to Europe for this purpose. The frogs were first kept in a quarantine station in Berlin, supervised by the veterinary specialist Frank Mutschmann. In so doing, we found evidence that the frogs were infected with the chytrid fungus, *Batrachochytrium dendrobatidis* — the first Chilean report of the fungus, which is implicated in the global decline of amphibians. Despite expert treatment, all of the frogs died within a few days to weeks after arrival.

Following this setback, we decided, in cooperation with the University of Concepción and financed largely by the Leipzig Zoo, to build a research and breeding station in the frogs' natural habitat. The University of Concepción provided us with a location on their property and construction (financed by the Leipzig Zoo) took place in the first half of 2009. The station, consisting of two laboratory and office containers and several generously proportioned outdoor enclosures, opened in May. While dedicated largely to the research and breeding of *Rhinoderma*, the station also is open to other herpetological work. Prof. Juan Ortíz directs the team of Chilean scientists, with Johara Bourke as a scientific consultant. At the invitation of the University of Concepcíon, Klaus Busse, currently the most experienced keeper of these frogs, traveled to Concepcíon at the end of 2009 to assist with establishing the population of Darwin's Frogs at the station.

Other projects are currently underway in Chile. One, in cooperation with the Atlanta Botanical Garden and Zoo and the University of Santiago, will attempt to establish a captive population within a sterile "frog container" at the Santiago Zoo. Another research group in Chile is addressing the chytrid fungus. All of these projects will be working closely together as part of a "*Rhinoderma* Task Force."

The problems are multifold. We do not know how far the chytrid fungus has spread among populations of Darwin's Frogs in nature. Investigations from the summer of 2009 at our research and breeding station in Concepción have confirmed further incidents of infection in the wild. We also do not know if the existing populations of Darwin's Frogs are declining or stable in the face of ongoing habitat destruction from clearcutting and dam construction. We also still do not know what happened to *R. rufum*. The future of these singular frogs, first discovered by Darwin during his historic voyage around the world, in this International Year of Darwin, seems more uncertain than ever.

Acknowledgements

I thank all donors and supporters of the *Rhinoderma* Project of *Reptilia* and ZGAP (Zoologische Gesellschaft für Arten- und Populationsschutz e. V.), in particular: *Reptilia*, the Leipzig Zoo, the Chester Zoo, Forschungsmuseum Alexander Koenig, the Amphibian Decline Task Force, Lucky Reptile/Peter Hoch Company, Natur und Tier - Verlag, and the North of England Zoological Society.

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Species of snakes that feed on skinks (such as the Oriental Whip Snake, *Ahaetulla prasina*) have independently evolved specialized mechanisms for grasping and holding them. These features include hinged maxillary teeth and gaps in tooth rows in which the skink's body is trapped.

New Faces from Ancient Places: Uncovering Peninsular Malaysia's Hidden Lizard Diversity Part II: Skinks

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All photographs by the author.

How many times have you walked along a shady forest trail and quickly turned to see what was rustling in the leaf litter — only to catch a glimpse of something dark and shiny, a split second before it darted behind a log or under a bush? Later, down that same trail, you could swear you caught a glint of something in the sunlight just before it circled around to the backside of a tree. Well, don't despair, it happens to all of us.

If you were in Peninsular Malaysia, more than likely what you saw was one of the region's 36 species of actively foraging, constantly moving skinks. This is really no surprise, given that the family Scincidae is the most diverse group of reptiles in the world. Upwards of 1,300 species are currently recognized, comprising nearly one-third of the world's known species of lizards. Also, as you might have guessed, skinks are most diverse in the tropics. They really are quite an amazing lot as well. Although they vary remarkably in anatomy and lifestyle, nearly all skinks have relatively long, shiny bodies and tails and, in many groups, exhibit an independent evolution of limb reduction and loss.

Most skinks are terrestrial and show an amazing array of anatomical and behavioral adaptations for living in restrictive microhabitats. In Peninsular Malaysia, the majority of skinks are forest-floor or climbing species, and a few are limbless or nearly limbless fossorial forms. All are covered with shiny scales, and each scale is underlain by a thin plate of bone called an osteoderm. This smooth, hard exterior makes skinks extremely durable and difficult to grab. In fact, many species of snakes that feed on skinks (such as the Oriental Whip Snake, *Ahaetulla prasina*) have independently evolved specialized mechanisms for grasping and holding them.

The striped pattern of *Larutia seribuatensis* might serve a protective function by creating a visual illusion that can confuse potential predators.

Unlike the newly described *Larutia seribuatensis*, which occurs at sea level and appears to be active on the surface, the new species' closest relative (*L. trifasciata*, illustrated here) is an upland fossorial cloudforest denizen.

These features include hinged maxillary teeth and gaps in tooth rows in which the skink's body is trapped.

I find researching skinks to be the ultimate test of my patience. Eight species in Peninsular Malaysia are known from three or fewer individuals. Countless are the times when I have crossed the Pacific Ocean to go to the places where they are supposed to occur, only to miss them. However, this is not to say I struck out. One of the great things about skinks is that they are good at partitioning environmental resources. Consequently, you can find a high number of species in one place. Even if that place has not been visited frequently, some of those species are likely to be new to science.

During my quests over the last five years to find rare species such as *Sphenomorphus cameronicus* in the Banjaran Titiwangsa or *Lipinia surda* in the Seribuat Archipelago, my team has been fortunate enough to discover and describe six new species of skinks, all of which are endemic to Peninsular Malaysia or its associated Archipelagos. One of the most interesting new skinks is a nearly limbless species of the genus *Larutia*. The Larut Skinks are named after Bukit Larut, the locality of the type species, *Larutia larutensis*. While surveying the satellite island of Tulai off the coast of Pulau Tioman in the Seribuat Archipelago, we found three specimens of a strange, snake-like skink beneath some surface debris and leaf litter. We quickly determined it to be a new member of the genus. What is most perplexing about this new species is that the five other species of *Larutia,* including the new species' closest relative, *L. trifasciata* from the Banjaran Titiwangsa, are all upland fossorial cloudforest lizards from Peninsular Malaysia, Sumatra, or Borneo — whereas this new species, which was named *L. seribuatensis,* was found at sea level in relatively arid conditions. Additionally, it had a complete striping pattern that suggests it spends a significant amount of time above ground moving through the leaf litter. As in striped snakes,

Some Peninsular Malaysian forest skinks, such as the Blotched Forest Skink (*Sphenomorphus praesignus*), are large, long-limbed, colorful, and diurnally active.

Other Malaysian species, such as the Bukit Larut Forest Skink (*Sphenomorphus butleri*), are small, brownish, nondescript, and secretive leaf-litter specialists with short limbs and elongate bodies and tails.

the striped pattern serves a protective function by creating a visual illusion that can serve to confuse potential predators.

The five other new species of skinks that my team and I discovered and described are all in the genus *Sphenomorphus,* the forest skinks. In Peninsular Malaysia, forest skinks fall into two broad categories. Some species, such as the Blotched Forest Skink (*S. praesignus*), are large, long-limbed, colorful, and diurnal terrestrial or climbing species whose foraging and basking behaviors make them conspicuous components of the ecosystems they inhabit. Others, however, such as the Bukit Larut Forest Skink (*S. butleri*), are small, brownish, nondescript, and secretive leaf-litter specialists with short limbs and elongate bodies and tails whose lifestyles leave them poorly understood and rarely seen. Most of these are upland or insular endemics, and our five new species all fall within this latter group of small skinks.

Sphenomorphus ishaki, the Pulau Tioman Forest Skink, is unique in that it is known only from higher elevations and is active only during cool, cloudy days.

Now, I admit that these skinks are not nearly as "cool" looking as some of our newly discovered geckos that have flaming yellow heads, electric white tails, and colorful banding patterns. However, these little skinks are equally exciting in a different way, mainly because they provide us with clues as to how evolution works. The fact that these geographically isolated species stuck on islands and mountaintops scattered all over Peninsular Malaysia look very similar to one another makes a bold statement about how natural selection operates on a common genotype shared between multiple species. In essence it says: "If you have the common genetic blueprint of *Sphenomorphus* and you are terrestrial, less than 50 mm in snout-vent length, and live in leaf litter, then you'll survive best if you look and behave like this." In fact, discerning one species from another is very difficult without a close, microscopic examination. So, for an evolutionary biologist, this is an exciting example of how evolution "edits" basic genetic material to produce a body plan and a lifestyle best suited to widely separated but similar environments.

Sphenomorphus bukitensis, the Titiwangsa Forest Skink, is so small and so secretive that it likely has a much more extensive distribution than that indicated by the few known individuals.

The only known example of *Sphenomorphus perhentianensis,* the Perhentian Forest Skink, was found foraging on the forest floor immediately following a heavy afternoon rain shower.

Four of the five new species of *Sphenomorphus* are insular endemics. *Sphenomorphus ishaki,* the Pulau Tioman Forest Skink, is unique in that it is known only from the upper elevations of Gunung Kajang and is abroad only during cool, cloudy days. This is a significant behavioral departure from most skinks, which are commonly active on hot, sunny days. Another, *S. sibuensis,* the Pulau Sibu Forest Skink, occurs at sea level in coastal vegetation that fringes the mangrove swamps on Pulau Sibu. It is known from only two specimens that were collected almost exactly one year apart under the exact same small log! This may indicate something about the extreme microhabitat specificity of this new species. The third insular endemic comes from Pulau Perhentian Besar of the Perhentian Archipelago. This species, *S. perhentianensis,* the Perhentian Forest Skink, is known from only a single specimen, but was sufficiently distinctive to warrant its own specific recognition. It was found foraging on the forest floor immediately following a heavy afternoon rain shower. It also is the only member of this group of skinks known from northeastern Malaysia. The remaining insular species comes from the Langkawi Archipelago, where it is known from Pulau Langkawi and the smaller, adjacent Pulau Singa Besar. Curiously, the Pulau Langkawi individual was found near the summit of Machinchang at an elevation of >750 m, whereas the lizard from Pulau Singa Besar, was found near sea level. Clearly this species' degree of microhabitat specificity is not nearly as restrictive as that of *S. sibuensis.* The last endemic species, *Sphenomorphus bukitensis,* comes from the Banjaran Titiwangsa. We found this species one night while turning logs at Fraser's Hill, and subsequently found it again farther north in the Cameron Highlands. This species is so small and so secretive that it likely occurs over the entire length of the mountain range. We just haven't looked hard enough yet to find it elsewhere.

So, what do all these new species described during the past five years indicate? Just like the geckos you may have read about in the last issue of *Reptiles & Amphibians*, it means that we have a long way to go before we really know just how many different species of skinks occur in Peninsular Malaysia. The fact that we have discovered and described many more new species of geckos than species of skinks merely reflects the reality that geckos are much easier to find and don't run nearly as fast. So, the next time you are walking along a forest trail and you hear something in the leaves and you just can't get a good look at it, it is probably a skink. It could even be a species we have never seen, although we may have heard it any number of times!

BOOK REVIEWS

West Indian Reptiles and Amphibians

Natural History of West Indian Reptiles and Amphibians. 2009. Robert W. Henderson and Robert Powell. University Press of Florida, Gainesville. xxiv + 495 pp. Hardback – ISBN 978-0-8130-3395-5. $85.00.

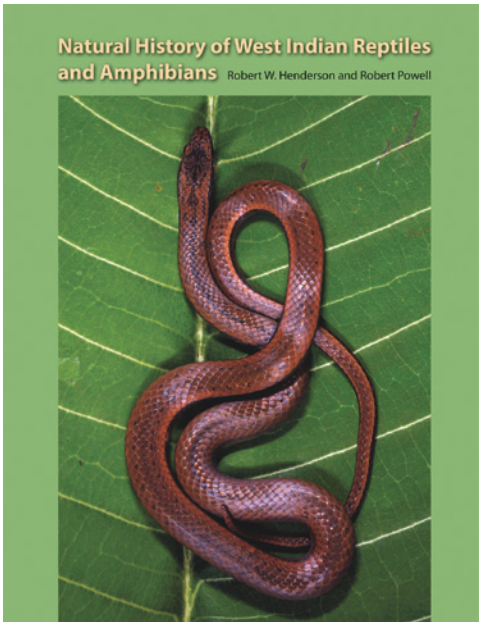
"Our final tally of 737 currently recognized species of frogs and non-avian reptiles (excluding marine turtles) in the West Indies might be outdated by the time this book is published …. Hedges (2006) … predicted that the total number of species would most likely exceed 800 …."

This is a monumental volume. The West Indies have been the focus of intense herpetological research for over two centuries. Most of that research effort has gone into taxonomic investigations, with only about 5% of the species receiving direct natural history research by 1990 when the predecessor of this book, Schwartz and Henderson (1991), was finished. Now Henderson and Powell reckon that nearly 43% of species have had at least some dedicated natural history research. So, however monumental, this tome is merely a milestone along our way: "Because we still know so little about so many of the frogs and reptiles of the islands, the West Indies collectively represent a natural laboratory that will continue to provide an unending stream of questions for many decades to come."

Indeed, for any aspiring herpetologist, this book can be the perfect source for ambition and inspiration. Just compare, for example, the text for a rather well known species like *Anolis sagrei*, with seven full double-column pages, and the gecko *Sphaerodactylus lazelli*, albeit described in 1968, with just 36 mm of text in one column. To put the picture in another perspective, *Anolis sagrei* gets about 1.4% of the book's entire text; a volume (or volumes) including that much information for 800 species would far exceed a thousand pages. Literally, we know almost nothing about the natural history of most species — and they are spread over at least 600 islands! This detailed chronicle of what we do know enables one to formulate terrific research protocols for hundreds of species "figuratively crying out for someone to seek answers."

Those answers are indeed being sought. The authors graph the increase in relevant published works per decade since 1740 when only one paper was written on West Indian amphibians and reptiles. In the 1960s, that had increased to near 200; in this first decade of century 21, the number is already almost 700 — and we are not even done!

The book is divided into three major sections: A 22-page introduction, an ending 89 pages of literature cited, and 382 pages of species accounts in the middle. The introduction is extensive and detailed, a must-read for anyone even passingly interested in the subject. Therein we are informed that the species accounts will, to the extent possible, include data on distribution, habitat, abundance, activity, behavior, biomass, competition, diet and foraging, dispersal, growth, home ranges, movements, parasites, population size and density, reproduction, sex ratio, size, caudal autotomy, thermal biology, and miscellaneous topics where relevant like ecomorphology, desiccation, and hurricane effects. Generally, pictures, identification characters, and maps are deferred to an upcoming field guide by S. Blair Hedges.



The introduction highlights conservation. Many West Indian species of frogs and reptiles are endangered or threatened, and too many are apparently extinct. This unfortunate and alarming situation is entirely — directly or indirectly — the result of human activity and human populations. Those escalating human numbers are creating "... rapidly deteriorating circumstances for some species." Almost three pages (pp. 8–11) are dedicated to human "Introduced Invasive Predators and Competitors." Although ants are mentioned herein, the introduced Fire Ant (*Solenopsis invicta*) is not explicitly discussed — now there is a topic for some avid researcher! The deleterious effects of human population are mentioned at least five times with respect to agriculture, housing, tourism, and other ramifications, prior to a section titled "Overpopulation" (pp. 16–17). Therein are given actual census and growth figures for several pivotal islands or countries. This is followed by a section on "Future Emphases" (p. 20) initiated by "overdevelopment [and] burgeoning human population ...." Henderson and Powell are to be especially commended for this: The entire ecological and conservation community must cease ignoring the "mother of all problems" — human overpopulation.

I have searched the species accounts long and hard for errors. The only one I have found is a weak, oblique inference (p. 77) of the presence of the frog *Eleutherodactylus schwartzi* on Guana Island (British Virgin Islands) where that species does not occur, although investigations of its congener *E. antillensis* on the island have been extensive, as noted in the book.

My own herpetological efforts in the West Indies span more than half a century; I take this opportunity to express my gratitude for this rich and wonderful book: It is most rewarding.

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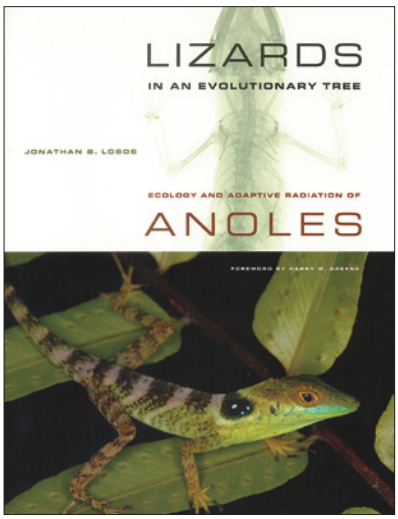
All You Ever Wanted to Know About Anoles — But Were Afraid to Ask

Lizards in an Evolutionary Tree: Ecology and Adaptive Radiation of Anoles. 2009. Jonathan Losos. University of California Press, Berkeley. xx + 507 pp. Hardcover – ISBN 978-0-520-25591-3. $75.00.

Over 350 species of anoles, characterized by colorful dewlaps and toe-pads that allow them to climb just about anything, occur in the West Indies, tropical Mexico, and Central and South America. Jonathan Losos first studied them as an undergraduate, and despite a few forays into other taxa, has remained mostly loyal to this absorbing group. This book is the product of his long-standing fascination with anoles, and draws on decades of his own scholarship and that of others. Every aspect of anole life is covered in this book: where they are found, what they eat, how they reproduce, and lots more. Despite the number of pages and the thorough scholarship, Losos manages to be informative in a candid, humorous, and often entertaining manner. Colorful pictures and graphs illustrate many of the species and subjects covered.

In his first chapter, Losos clearly sets out his basic thesis: "interspecific interactions — primarily, but not exclusively, competition — among extant *Anolis* species play a dominant role in shaping their ecology and microevolution." Chapters 2–4 focus on natural history, ecology, and diversity of anoles, and chapters 5–7 on phylogeny and the use of phylogenetic insights in understanding distribution and ecomorphology. The following five chapters deal with anole biology, ecology, reproduction, food and predators, and behavior. Sexual selection, so important in these intensely territorial lizards, receives special notice. Speciation and adaptive radiation are the focus of chapters 14–16, and the final chapter seeks to place anoles in a broader context. Although Losos clearly expresses his own opinion, he is careful to admit the limitations of the available data. *Lizards in an Evolutionary Tree: Ecology and Adaptive Radiation of Anoles* does not contain *all* there is to know about anoles — thankfully, many questions remain — and most of the chapters have a "Future Directions" section at the end.

Anoles offer several delightful conundrums. They have extremely conservative reproduction — only one egg per clutch — yet have evolved a set of morphological "types" that allow them to use a variety of habitats. The relevant ecological and evolutionary processes are easy to accept in this setting, given the repeated evolution of particular size and shape categories on some islands. However, those same morphotypes are hard to find on the mainland. Anoles evolved into one of the most diverse genera (with many species occurring in vast numbers) throughout most of their range, yet only one species was found in North America until a growing number of new arrivals became established in Florida and elsewhere, invariably with human assistance. Losos does not claim to have all the answers, but he correctly points out that anoles are not just fun and fascinating, they serve as a natural laboratory in which to explore processes that are likely to be globally important — in effect, they are what biologists like to call "a model system." Over 70 pages of references attest to both the interest in this group and the author's painstaking search for published information.



The word "conservation" seldom appears in the book and is absent from the 12-page index. To some extent this is perfectly understandable, since most anoles are quite common in areas where they occur. Yet the habitats on which many species rely are rapidly disappearing. In Haiti, as Losos describes on pages 403–404, less than 1% of forest cover remains. Several species, such as *A. roosevelti* in the Puerto Rico Bank, have already gone extinct, and global climate change, covered on pages 404–406, promises increasing challenges in the future. "As far as I know," Losos says, "anoles are not eaten by people anywhere. For good reason, as I imagine they'd be pretty crunchy." Even though some species are abundant in the pet trade, little evidence suggests a direct impact on populations. The converse, however, is definitely true; anoles are establishing populations in many new locations, and some seem particularly adept at utilizing urban environments.

So, is this book for you? The goal of this journal is to bridge the gap between professional herpetologists and serious enthusiasts. Because our audience is so diverse, a review of this kind always risks missing a large portion of the readership. To provide similarly broad views, one of us (GP) is an academic herpetologist and the other (LG) is not. Luckily, Losos had two audiences in mind for this book, those who have a deep interest in anoles and those who have an interest in biodiversity, evolutionary biology, and ecology. This, the author's obvious enthusiasm for his subject, and his frequent use of informal language allow the book to appeal to a broad audience. Our verdicts: "Initially, I thought it was too thick and would take a long time to read, but the old cliché fits here, never judge a book by its cover. I glanced through it quickly and saw many large colored photographs, and the print was not tiny. That was encouraging. Whether Losos is discussing the dewlaps or the toe-pads, he presents an image that illustrates that information, making the 400-page book easier to read and comprehend" (LG). "An excellent, exhaustively-researched, yet very accessible and attractive contribution" (GP). If you have any interest in learning about herpetological ecology and biodiversity, this is a great book to buy.

This review is MS No. T-9-1185 of the College of Agricultural Sciences and Natural Resources, Texas Tech University.

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CONSERVATION RESEARCH REPORTS

Effects of Rattlesnake Roundups on the Eastern Diamondback

Gassed out of Gopher Tortoise burrows for roundups, the Eastern Diamondback Rattlesnake (*Crotalus adamanteus*) has declined in the southeastern part of the United States during the last two decades. Initially held for excitement and adventure and as a competition to diminish snake populations, roundups today are being motivated by economic concerns. Snake venom, flesh, and skin are in high demand. **MEANS** (2009. *Herpetological Conservation and Biology* 4:132–141) analyzed the data on size and numbers of rattlesnakes for four roundups in the southeastern U.S. (Opp, Alabama and Whigham, Fitzgeralds, and Claxton, Georgia) spanning a period of 50 years (1959–2008). Both numbers of snakes and weights of the largest snakes that participants turned in annually declined in the last two decades. Statements by roundup officials and rattlesnake hunters support that roundup hunting has depleted local rattlesnake populations and forced hunters to travel farther to collect snakes in recent years. Declining maximum sizes of snakes reflect possible age-class truncation, whereby collectors cull older, larger individuals of this long-lived species. Roundups reduce their populations and perpetuate negative attitudes about venomous snakes, whose skins and flesh are subject to high commercial demand. Before the Eastern Diamondback Rattlesnake becomes threatened throughout its range, state wildlife agencies should either ban the taking of individuals or regulate their taking by developing bag limits and seasonal harvest guidelines. The Eastern Diamondback Rattlesnake would further benefit by refocusing extant roundups as wildlife festivals in which participants celebrate rattlesnakes and other wildlife rather than exploit them. Alternatively, roundups could change their theme entirely (such as one roundup that became a Wild Chicken Festival).

SUZANNE L. COLLINS, CNAH

Rattlesnake roundup hunting has depleted local Eastern Diamondback Rattlesnake (*Crotalus adamanteus*) populations and forced hunters to travel farther to collect snakes in recent years.

Imperiled Map Turtles in Mississippi

Species distribution and abundance is often difficult to delineate due to species factors (e.g., crypsis, low abundance) or sampling techniques. Species of the genus *Graptemys* are primarily riverine turtles and have historically been subject to declines because of anthropogenic changes to their habitats. Therefore, to better inform conservation efforts, **SELMAN AND QUALLS** (2009. *Herpetological Conservation and Biology* 4:171–184) thoroughly studied the distribution and abundance of two imperiled *Graptemys* species within the Pascagoula River System in Mississippi: Yellow-blotched Sawbacks (*Graptemys flavimaculata*) and Pascagoula Map Turtles (*Graptemys gibbonsi*). They studied turtle populations in 17 counties in southeastern Mississippi using four methods: Mark-resight population surveys (three populations), bridge surveys (160 bridge crossings), basking density surveys without marked individuals (23 localities), and trapping (three populations). *Graptemys flavimaculata* was present throughout its historical range, as well as in new drainage localities; abundance in historically surveyed areas was generally higher than previous surveys had reported. *Graptemys gibbonsi* also was found in many new localities and occurred in most of the drainages of the Pascagoula River system. However, abundance was much lower for *G. gibbonsi* than for *G. flavimaculata* throughout the system and individuals were not found in several historical localities, suggesting localized extirpations. The authors recommended that *G. gibbonsi* be listed as state Endangered in Mississippi and Louisiana, U.S. federally listed as Threatened, and upgraded to Endangered (EN) under IUCN listing guidelines. Future conservation measures should extend to protect additional riparian habitat throughout the Pascagoula River system and future surveys of other *Graptemys* species are warranted due to the imperiled status of this genus.

SUZANNE L. COLLINS, CNAH

Yellow-blotched Sawbacks (*Graptemys flavimaculata*; top) are present throughout their historical range, as well as in new drainage localities. Pascagoula Map Turtles (*Graptemys gibbonsi*; bottom) also were found in many new localities and occurred in most of the drainages of the Pascagoula River system.

Demographics of an Isolated Population of a Threatened Salamander in Illinois

Amphibian populations that use small isolated wetlands often are small in size, susceptible to stochastic extinction processes, and have little to no contact with other populations. One can ascertain the persistence of such populations only by obtaining data that allow the prediction of future changes in a population's size and a propensity to achieve a sustainable number of individuals. The number of metamorphosing larvae leaving a pond predicts the viability of a salamander population, and thus, the number recruited into the terrestrial adult population. Jefferson Salamanders (*Ambystoma jeffersonianum*) are listed as a threatened species in Illinois, occurring at fewer than 15 ponds statewide. In 2004 and 2005, at an isolated breeding pond in Lincoln Trail State Recreation Area, **Mullin and Klueh** (2009. *Herpetological Conservation and Biology* 4:261–269) determined the number of egg masses, average percentage of successfully hatched eggs, and number of juveniles leaving the pond. They incorporated those data into a matrix for a stage-based population model, which predicted that, on average, the population at the LTSRA pond would persist for four more years, with survivorship from larvae to juvenile being the most important parameter. Increasing survivorship during the larval period increased abundance as well as average persistence time. Active management at the breeding pond to increase the time available for successful metamorphosis might facilitate persistence of the salamander at this site.

SUZANNE L. COLLINS, CNAH

Studies have projected that populations of Jefferson Salamanders (*Ambystoma jeffersonianum*) in ponds at the Lincoln Trail State Recreation Area in Illinois would persist for only four more years.

Invasive Cane Toads Increase Mortality of Australian Varanids

Exotic animal and plant species introduced into the Australian continent often have imparted catastrophic effects on the indigenous fauna and flora. Proponents of biological control introduced the South American Cane Toad (*Bufo marinus* [= *Rhinella marina*]) into the sugar cane fields of Queensland in 1935. The Cane Toad is one of the most toxic bufonids, and when seized by naïve Australian predators, the toxin usually kills the attacker.

JEANETTE COVACEVICH

Nine of nine radio-tracked Yellow-spotted Goannas (*Varanus panoptes*) were found dead in August 2006, most likely after attempting to feed on invasive Cane Toads (*Bufo marinus* [= *Rhinella marina*]).

Australian varanid lizards are particularly susceptible to Cane Toad toxins. Prior to the Cane Toad invasion of the Adelaide River floodplain of the Northern Territory of Australia, **Ujvari and Madsen** (2009. *Herpetological Conservation and Biology* 4:248–251) recorded a very low annual mortality (2 deaths among 20 lizards over 3 years) of adult male radio-tagged Yellow-spotted Goannas (*Varanus panoptes*). After the arrival of the toads in October 2005, all (9 of 9) radio-tracked lizards were found dead in August 2006, most likely after attempting to feed on toads. Those results suggest that invasive Cane Toads place naïve adult male Yellow-spotted Goannas at risk of very high mortality (possibly >90%). This increase in mortality could reduce the genetic diversity and hamper long-term survival of these large carnivorous lizards.

Jamaican Iguanas Bred in North America

The Jamaican Iguana (*Cyclura collei*) was considered to be extinct until its rediscovery in 1990 in the Hellshire Hills region of Jamaica. Between 1994 and 1996, several wild caught juveniles were placed in six North American zoological institutions including the Indianapolis Zoo. The intent was to establish a self-sustaining captive population outside of Jamaica in order to serve as an ancillary population should the wild numbers decline. **Searcy et al.** (2009. *Zoo Biology* 28:343–349) manipulated several environmental parameters such as temperature, humidity, photoperiod, and diet to encourage reproduction in captivity. In 2006, two clutches of eggs were deposited by two separate females for a total of 35 eggs. Twenty-six eggs were fertile and 22 hatched after a 76–83-day incubation at 30.3–30.8 °C (86.5–86.7 °F). The average weight of the neonates was 26.4 g and the average total length was 21.7 cm. This successful reproduction of *C. collei* constitutes the first North American hatching for this species. Environmental parameters, incubation techniques, and neonate morphometry can serve as a baseline for further propagation of the species. This represents a positive milestone for the continuing conservation of this critically endangered species.

JOHN BINNS

The successful reproduction of Jamaican Iguanas (*Cyclura collei*) at the Indianapolis Zoo constitutes the first North American hatching for this species.

NATURAL HISTORY RESEARCH REPORTS

A New Genus and Species of Salamander from the United States

Camp et al. (2009. *Journal of Zoology* 279:86–94) described a striking new species of the lungless salamander family Plethodontidae from the Appalachian foothills of northern Georgia. The new species is named *Urspelerpes brucei*, and the authors' suggested common name is the Patch-nosed Salamander. This miniature species (ca. 25–26 mm adult standard length) is so distinctive genetically and morphologically that the authors erected a new genus, the first new genus of amphibian described from the United States in nearly 50 years. The species is unique among plethodontids from eastern North America in displaying sexual color dimorphism. Also, although many miniaturized plethodontids exhibit a reduced number (four) of digits on the pes, this species possesses a full complement of five toes. A plethodontid phylogeny derived from mitochondrial and nuclear DNA sequences places it in the tribe Spelerpini as the sister taxon to *Eurycea*. Genetic divergence between the new species and *Eurycea* for the nuclear gene Rag-1 (4.7%) is among the higher levels observed between long-established spelerpine genera (2.6–5.3%). This new form appears to be rare and is of immediate conservation concern.

TRIP LAMB

An adult male *Urspelerpes brucei* (top) and an adult female from Stephens County, Georgia.

JASON BOND

A larval *Urspelerpes brucei*.

A New Species of Iguana from Honduras

Hasbún and Köhler (2009. *Journal of Herpetology* 43:192–204) described a new species of *Ctenosaura* from the Pacific versant of southeastern Honduras (Departments of Francisco Morazin and Choluteca). The new species, named *Ctenosaura praeocularis*, occurs in a restricted area between the ranges of *C. flavidorsalis* (southwestern Honduras, El Salvador, and southeastern Guatemala) and *C. quinquecarinata* (Nicaragua and Costa Rica). The new species differs from C. *quinquecarinata*, *C. oaxacana*, and *C. flavidorsalis* in scalation, osteology, and coloration. The suggested phylogenetic relationships of the new species are ((*C. flavidorsalis* + *C. praeocularis*) + (*C. quinquecarinata* + *C. oaxacana*)). Iguanas of the new species were found mostly in hollow trees and branches no more than 2 m above the ground. The habitat was dominated by shrub and tree vegetation. These lizards feed mainly on young leaves and insects. Local people occasionally hunt them for food and consider them to have become rarer in the last two decades, primarily because of habitat loss.

GUNTHER KÖHLER

Ctenosaura praeocularis is a new species of Spiny-tailed Iguana recently described from southern Honduras.

Railroad Tracks Block Gene Flow in Marbled Salamanders

Habitat fragmentation reduces gene flow between isolated populations, thus increasing the risk of extinction through reduced genetic diversity due to the possibility of inbreeding and genetic drift. Ambystomatid salamanders are known to have limited vagility and high breeding site fidelity, rendering them especially prone to the negative effects of fragmentation. **Bartoszek and Greenwald** (2009. *Herpetological Conservation and Biology* 4:191–197) compared gene flow between two populations of Marbled Salamanders (*Ambystoma opacum*) that are separated by railroad tracks. They also compared the genetic diversity of one population across two consecutive years. Observed heterozygosities within sites indicated that the populations may be inbred, and additional results corroborated the interpretation of semi-isolated populations. Over 60% of individuals were correctly assigned as residents, whereas only two individuals at each site were identified as immigrants. These data suggest that the railroad track may act as a barrier to gene flow in these two populations.

SUZANNE L. COLLINS, CNAH

Barriers as seemingly inconsequential as a railroad track may act as a barrier to gene flow between populations of Marbled Salamanders (*Ambystoma opacum*).

Turtle Vocalization

Narrow-breasted Snake-necked Turtles (*Chelodina oblonga*) are long-necked, freshwater turtles found predominantly in the wetlands on the Swan Coastal Plain of Western Australia. Turtles from three populations were recorded from dawn to midnight in artificial environments set up to simulate small wetlands. **Giles et al.** (2009. *Journal of the Acoustical Society of America* 125:434–443) described a vocal repertoire of 17 categories with calls consisting of both complex and percussive spectral structures. Vocalizations included clacks, clicks, squawks, hoots, short chirps, high short chirps, medium chirps, long chirps, high calls, cries or wails, hooos, grunts, growls, blow bursts, staccatos, a wild howl, and drum rolling. Also, a sustained vocalization, hypothesized to function as an acoustic advertisement display, was recorded during the breeding months, consisting of pulse sequences that finished rhythmically. These turtles often live in

environments where visibility is restricted due to habitat complexity or poor light transmission attributable to tannin-staining or turbidity. Thus the use of sound by turtles may be an important communication medium over distances beyond their visual range.

GERALD KUCHLING

Narrow-breasted Snake-necked Turtles (*Chelodina oblonga*) have a vocal repertoire of 17 categories with calls consisting of both complex and percussive spectral structures.

A New Land Iguana from the Galápagos

Gentile and Snell (2009. *Zootaxa* 2201:1–10) described *Conolophus marthae*, a new species of land iguana endemic to Volcan Wolf of northern Isla Isabela in the Galápagos Archipelago. The new species is morphologically, behaviorally, and genetically distinguished from the other two congeneric species *C. subcristatus* and *C. pallidus*. Besides the taxonomic implications, *C. marthae* is extremely important as it provides evidence of a deep divergence within the Galápagos land iguana lineage.

Gila Monsters and Urbanization

To assess whether urbanization influences the spatial ecology of a rare and protected venomous reptilian predator, the Gila Monster (*Heloderma suspectum*), **Kwiatkowski et al.** (2008. *Journal of Zoology* 276:350–357) compared home range (HR) size and movement parameters at three Sonoran Desert sites varying in degrees of urbanization. The authors predicted that the urban population of *H. suspectum* would exhibit smaller HRs, avoid human structures, and show less movement. Multivariate analysis indicated that males generally exhibited larger HRs and had higher movement rates and activity levels than females at all three sites. Contrary to the authors' predictions, however, HR size and movement parameters did not vary across the sites in relation to the level of urbanization. At the urban site, individuals often crossed narrow roads and regularly used artificial structures as refuges for extended periods. Water and prey, including the eggs of ground-nesting birds and neonatal mammals (rodents and rabbits), are common in human altered environments, facilitating the adaptation of Gila Monsters to those areas. Furthermore, the population sex ratio at the urban site was female-biased, consistent with the expectation that occupation of larger HRs and higher movement rates result in higher mortality for males in urbanized areas. Gila monsters did not appear to alter certain aspects of their spatial ecology in response to low levels of human activity but additional work will be required to assess population viability and possible effects in the long term and with higher levels of urbanization.

ERIK BETTINI

Home range size and movement parameters of Gila Monsters (*Heloderma suspectum*) did not vary in habitats subjected to various levels of urbanization.

Color Affects Social Costs

Australian Painted Dragon Lizards (*Ctenophorus pictus*) come in three head colors: red, orange, and yellow. In addition, some individuals have skin flaps called bibs hanging from their necks. **Healey and Olsson** (2009. *Austral Ecology* 43:636–640) demonstrated that some lizards suffer a higher 'social cost' than others. Red and orange males with a bib have better body condition than red and orange males without bibs. In contrast, yellow males who lack bibs have a better body condition than yellow males with bibs. Especially red males are more aggressive and have higher testosterone levels than yellow males. When

GABRIELLE GENTILE

The Pink Galápagos Land Iguana (*Conolophus marthae*) was formally described as a new species from Volcan Wolf on Isla Isabela.

PETER HARLOW

Head color in male Australian Painted Dragon Lizards (*Ctenophorus pictus*) elicits a 'social cost' in some individuals.

exposed to a high number of aggressive neighbors (red), all males suffer losses in body condition, but those with bibs experience more severe losses — especially yellow males. Exposure to red neighbors incites confrontations and fights, disproportionately affecting and thus eliciting a higher 'social cost' in yellow males with bibs.

Effects of Human Encounters on Cottonmouths

The increased encroachment of humans into natural areas is typically viewed as stressful for many wildlife species. A common stress response of many animals, including snakes, is the elevated release of the adrenal hormone, corticosterone. To test whether human encounters elicited a stress response in snakes, **Bailey et al.** (2009. *Journal of Herpetology* 43:260–266) monitored the levels of circulating corticosterone in free-ranging Cottonmouths (*Agkistrodon piscivorus*) during staged interactions. When exposed to a high-level disturbance (i.e., capture and confinement in a bag) for 30 min, Cottonmouths exhibited a significant corticosterone stress response as predicted. This response was four times that of the control treatment (i.e., immediately bled snakes) and showed that Cottonmouths exhibit strong corticosterone responses to confinement. Conversely, blood corticosterone values for low-level disturbance (i.e., nearby human presence for 30 min) did not differ significantly from the control treatment. The lack of a strong stress response to low-level disturbance indicated that Cottonmouths possess a seemingly adaptive mechanism of not being overly alarmed by the mere presence of a potential predator. This suggests that the occasional foot-path encounters humans commonly have with snakes may not be stressful for some species.

GENEVIEVE POWELL

Capture and confinement in a bag for 30 minutes elicited a much greater stress response in Cottonmouths (*Agkistrodon piscivorus*) than capture, extraction of a blood sample, and release.

NEWSBRIEFS

Tadpoles Feast on Eggs

In April 2009, 50 endangered Mountain Chickens (*Leptodactylus fallax*), large frogs now restricted to only two West Indian islands, were airlifted from Montserrat after a deadly fungus swept through the island, devastating the population. Now several breeding programs are under way to save the frogs. Once numbers have been boosted in captivity, researchers hope to reintroduce the frogs back into the wild within the next two years.

Remarkable footage (http://news.bbc.co.uk/2/hi/8185125.stm), testifying to the success of the captive breeding programs, was recorded at the Durrell Wildlife Conservation Trust, in Jersey, which took in 12 of the rescued frogs. Twenty-six others went to Parken Zoo in Sweden, and 12 are now housed in ZSL London Zoo.

So far, four pairs of Mountain Chickens have started to breed, which could result in hundreds of frogs — and this has given researchers an insight into the way that these unusual amphibians care for their offspring. Professor John Fa, director of Durrell, said: "Mountain Chickens have very peculiar breeding habits because they form foam nests in burrows in the ground." The females lay their eggs in these nests, which eventually hatch into tadpoles. However, as the nests are underground, food is scarce — so the frogs need to find a way to provide nutrition for their young. Professor Fa explained: "In the case of Mountain Chickens, we have discovered that the female comes into the nest and starts laying a string of infertile eggs.

"We thought that the eggs would come out and drop to the bottom of the nest and then the tadpoles would start eating them, but the footage shows about 40 tadpoles congregating around the female and eating the eggs as they come out of the female's body. Every now and again, the female uses her back legs to push the tadpoles away from her body so another set can come up and eat as much as they can." He added: "It is really weird — it is an alien scene. This is the first time we have caught this on film."

MATT GOETZ, DURRELL WILDLIFE CONSERVATION TRUST

Mountain Chicken (*Leptodactylus fallax*) tadpoles feed voraciously on strings of infertile eggs laid by females for that purpose.

The Mountain Chicken is one of the world's most threatened frogs. The frog is so called because its meat tastes like chicken. It once was found on seven Caribbean Islands, but thanks to hunting and environmental pressures it is currently found only on Montserrat and Dominica. Now, however, the deadly chytrid fungus, which has devastated amphibian populations around the globe, has also ravaged Dominica's Mountain Chickens. The fungus was first detected on the island in 2002, and within 15 months, 80% of the Mountain Chicken population had been obliterated.

Conservationists were extremely concerned when they found that the chytrid fungus had spread to Montserrat earlier this year, and was sweeping quickly through the Mountain Chicken population. The team made a decision to airlift some of the last healthy frogs and bring them into captivity in a bid to save the creatures from extinction. Professor Fa said: "Things are not going terribly well in Montserrat because chytrid has now infected the safe population — or at least the one we thought was safe."

The breeding success has offered scientists a ray of hope in an otherwise bleak sit-

uation, and they are now concentrating on increasing the frogs' numbers. They hope to eventually release the captive Mountain Chickens back to their native home of Montserrat, and are currently looking for sites that are free of the deadly fungus. However, Professor Fa said: "If that doesn't work, if the area is infected, we will have to think again, and it could be that we take the animals to another island. Within a year or two we have to get these animals back to the wild. The longer you keep them in captivity, the more difficult it is for them to enjoy a life in the wild again."

Rebecca Morelle
Science reporter, BBC News

Deadly Frog Fungus Targeted by Amphibian Experts

The world's leading amphibian experts have come together and for the first time identified two major conservation initiatives to stop amphibians from going extinct. A new coalition of organizations, the Amphibian Survival Alliance, will be established to focus on containing the spread of the amphibian chytrid fungus and on protecting habitats that are home to amphibians that occur nowhere else in the world.

Amphibians are the most threatened group of animals in the world, with one in three of the 6,000 recognized amphibian species at risk of extinction. "The world's amphibians are facing an uphill battle for survival," says James Collins, Co-Chair of the IUCN Amphibian Specialist Group. "Infectious diseases, habitat loss, climate change, introduced species, commercial use, and pollution all affect amphibian survival. By far the worst threats are infectious disease and habitat destruction — so the Alliance will focus on these issues first."

The alliance, proposed at the first Amphibian Mini Summit at the Zoological Society of London in August 2009, brings together amphibian specialists working in the wild and those in zoos, aquariums, and botanical gardens. "If we want to stop the amphibian extinction crisis, we have to protect the areas where amphibians are threatened by habitat destruction," says Claude Gascon, Co-Chair of the IUCN Amphibian Specialist Group. "One of the reasons amphibians are in such dire straits is because many species are found only in single sites and are therefore much more susceptible to habitat loss."

DAVID VIEITES

The Amphibian Coalition seeks to prevent the spread of the chytrid fungus to new places, such as Madagascar, home of Guibe's Treefrog (*Guibemantis guibei*), which so far shows no evidence of the presence of the disease.

Curbing the spread of the amphibian chytrid fungus also is a top priority for the amphibian experts. This effort will focus on identifying the presence of naturally occurring bacteria, which seem to render some amphibians resistant to the killer frog disease, and investigating their use in managing the disease in other species. So far, these bacteria have only been found on a few species, so this approach needs more research.

Anti-fungal drugs to combat the deadly disease, exploring resistance in captive-bred populations, and translocations all need to be investigated. The alliance will look into policies to prevent the spread of the fungus to new places, such as Madagascar, which so far shows no evidence of the presence of the amphibian chytrid fungus.

"Amphibians have so much to offer humans," says Simon Stuart, Chair of the IUCN Species Survival Commission and convenor of the Amphibian Mini-Summit. "Many have an arsenal of compounds stored in their skins that have the potential to address a multitude of human diseases. However, opportunities are being lost, such as the Southern Gastric Brooding Frog, which could have led to the development of a medicine for human peptic ulcers, had it not gone extinct. We simply cannot afford to let this current amphibian extinction crisis go unchecked."

The new Alliance will work with partners to implement the Amphibian Conservation Action Plan and to raise the profile of amphibians in 2010, the International Year of Biodiversity.

IUCN
25 August 2009

Recovery Plan for Philippine Crocodiles

On 31 July 2009, 50 captive-bred Philippine Crocodiles (*Crocodylus mindorensis*) were released into the wild in Dicatian Lake, Barangay Dicatian, Municipality of Divilacan, Isabela Province, Luzon Island. The Philippine Crocodile, which is endemic to the Philippines, is one of the most severely threatened crocodilian species in the world. It is listed as Critically Endangered on the IUCN Red List of

MARCUS LINDSTRÖM

The Philippine Crocodile (*Crocodylus mindorensis*) is one of the most severely threatened crocodilian species in the world.

Threatened Species. The total population surviving in the wild is estimated at only 100 mature individuals and is restricted to northern Luzon and southwestern Mindanao.

Philippine Crocodiles are relatively small and pose no danger to humans unless provoked. The released crocodiles were bred in the Palawan Wildlife Rescue and Conservation Center (PWRCC) of the Department of Environment and Natural Resources (DENR). The Isabela-based Mabuwaya Foundation implemented a community-based crocodile conservation program with funding from the UK-registered Rufford Maurice Laing Foundation. The released crocodiles are about 1.2 m long. Ten crocodiles were fitted with radio transmitters. Their movements and adaptation will be monitored by the Mabuwaya Foundation and the DENR to gather more scientific information as a basis for future crocodile reintroductions elsewhere.

The Barangay Council of Dicatian approved the reintroduction and declared the lake a Philippine Crocodile sanctuary through a Barangay ordinance. The Local Government Unit of Divilacan also has supported the release of crocodiles in the lake. No people live along the lake, which is surrounded by forest. Nature-loving tourists are welcome to visit the lake and see wild Philippine Crocodiles and other endemic wildlife up close. An observation tower and campsite have been constructed next to the lake. The small ecotourism project is expected to provide benefits to the local community living near the lake and to the municipality of Divilacan.

Dicatian Lake is situated in the Northern Sierra Madre Natural Park (NSMNP), the largest and most biologically diverse protected area of the Philippines. The NSMNP has gained even more importance with this crocodile reintroduction, and now protects the largest single Philippine Crocodile population in the wild.

The release of 50 Philippine crocodiles in Dicatian Lake is a major step towards a recovery of the wild population and the future survival of this species. The reintroduction event was led by Mayor Venturito Bulan of Divilacan, Barangay, Captain Felino Libunao of Dicatian, Director Glenn Rebong of the Palawan Wildlife Rescue and Conservation Center, Josie De Leon of the Protected Areas and Wildlife Bureau, Merlijn van Weerd of the Mabuwaya Foundation (and member of the IUCN SSC Crocodile Specialist Group), invited guests, local governmental officials, and community members.

IUCN
10 August 2009

New Species in the Greater Mekong at Risk of Extinction

A bird-eating fanged frog, a gecko that looks like it's from another planet, and a bird that would rather walk than fly are among the 163 new species discovered in the Greater Mekong region last year. All are now at risk of extinction because of global climate change, according to a new report by the World Wildlife Fund. The Close Encounters report is the second new species report on this region. The new species were identified by scientists in the jungles and rivers of the Greater Mekong region of southeastern Asia. The 163 newly discovered species consist of 100 plants, 28 fish, 18 reptiles, 14 amphibians, 2 mammals, and a bird. Recent studies show the climate of the Greater Mekong region is already changing. Rising seas and saltwater will be devastating to coastal areas. The United Nations are scheduled to agree on a new global climate treaty at the Copenhagen Climate Summit, scheduled for this December.

DAVID MCLEOD

A new frog species for Thailand, *Limnonectes megastomias*, is an opportunistic-eater, lying in wait for its prey in streams. The species has a diverse diet that includes other frogs and insects — and even birds. The species has a disproportionately large head and a mouth equipped with "fangs." The fangs, which males use in male-to-male combat, are actually growths that protrude from the jawbone. Unlike many other species of frogs, males are larger than females. These frogs have been found only at medium-to-high altitudes (600–1,500 m) in three isolated and remote protected areas in eastern Thailand.

Editor's Remarks

A New Section on Invasive Species

Invasive species are second only to habitat alteration and destruction as a cause of declining biodiversity. Although introductions of amphibians and reptiles to localities where they do not occur naturally often appear to occur without catastrophic consequences, notable exceptions (i.e., Cane Toads throughout the tropics and pythons in Florida) have been documented. However, much of the problem today is in the sheer number of relocated species of amphibians and reptiles. As that number increases, awareness of their impacts and of the need to better understand what species are being moved, where they are going, and how they are getting there, also is growing. One problem is that most existing reports focus on well-established invaders. This omits information on unsuccessful introductions and, because of the time delay before invaders become a nuisance, typically means that the method of arrival can no longer be identified. Since the demise of the journal *Applied Herpetology*, no venue is dedicated to publishing and disseminating such information. Because the obvious conservation implications complement the goals of the IRCF, *Reptiles & Amphibians* will provide a peer-reviewed outlet for information on new human-aided range expansions of amphibians and reptiles, providing crucial data for managers devising methods for preventing or reducing potentially negative impacts. Check the IRCF website in early 2010 for details.

The Editors of *Reptiles & Amphibians*

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EDITORIAL

Florida Constrictors Unleash a Brouhaha

JENNIFER L. STABILE

Herpers are usually a friendly lot, more interested in a beer than a fight. This makes the current brouhaha over Florida and the possible future distributions of big snakes all the more unusual — and unpleasant.

The story has unfolded largely in Florida, which has long been the poster-child for non-native herp populations. Most of them have had little obvious impact, and generally have been considered harmless. Things changed when large constrictors were reported from the Everglades with increasing frequency. By the time the "powers-that-be" were willing to admit that this was a problem, the snakes had expanded their range and had begun eating endangered species. When an escaped domestic pet python killed a child, the scale of the problem was too large for comfort.

The U.S. Geological Survey was asked to identify the scale of the problem and offer solutions. One of their approaches was to model how much farther these species might spread based on the climate of native habitats. The models produced remarkably broad worst-case-scenario distributions, alarming all involved. The models used for such studies have assumptions and limitations, so their predictions have broad margins of error. Hiding behind this uncertainty, however, is as wrong in this case as it is when discussing global climate change.

Unfortunately, some in the herpetocultural community responded by declaring a personal war on the authors of the report. Presumably, the underlying cause was a fear that the possession of such animals would be banned.

This journal and its editors have long felt that responsible pet ownership is highly beneficial, encouraging the love and conservation of reptiles and amphibians. Nonetheless, research has long suggested that the origin of most introduced herpetological populations is the pet trade, and we have long been concerned with the less-responsible elements of the trade. The current fracas is a good example of the complexities involved when persons who presumably share a common interest are in conflict.

A boa or a python can be a great pet, but these large constrictors should not be loose outside of their native ranges. Most released and escaped pets die, and we consider this a great shame. Unfortunately, those that survive can become pests, impacting other species and hurting the image of herpetology as a whole, an equally great shame. In this no-win situation, the only solution lies in all interested parties coming together and developing a reasonable plan that eliminates — or at least greatly reduces — the likelihood that such animals are released in places where they do not belong.

We support measures that help reduce the risks of animals escaping or being inappropriately released, but consider outright bans on any particular species to be a last resort, not the first line of defense. Most of all, we deplore the rude and divisive tone that some in our community have taken in this case. It is unproductive, it is unprofessional, it is unscientific, and — most of all — it is lacking in basic civility.

The Editors of *Reptiles & Amphibians*

The capture of five African Rock Pythons (*Python sebae*) near the Everglades suggests that yet another species of large constrictor might be established in southern Florida. African Rock Pythons caught or sighted recently include a 12-foot adult, a hatchling, a two-foot snake that had eaten a Common Grackle, a large snake that had eaten a backyard turkey, and a large pregnant female run over by a car. This individual was photographed in Africa.