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## A History of Gila Monster (*Heloderma suspectum cinctum*) Records from California with Comments on Factors Affecting their Distribution

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*Abstract.*—The Gila monster (*Heloderma suspectum*), widely distributed in parts of the Mojave, Sonoran and Chihuahuan Deserts of the southwestern United States and northwestern Mexico, is rare in California. However, during the last 153 years, as many as 26 credible records have been documented from four California counties. Habitat in which the species has been observed in California is characterized by rocky, deeply incised topography, in most cases, associated with large and relatively high mountain ranges. Most localities are associated with riparian areas (including the lower Colorado River) and range from near sea level to over 1,200 m. All records except one (Mojave River) occur east of about 116° longitude. Records documented with photographs or museum specimens generally show color patterns diagnostic of the geographically expected subspecies *H. s. cinctum*. The distribution of the species in California suggests an invasion into the high mountain ranges of the northeastern Mojave during the last interglacial via the Colorado River corridor. We explored the hypothesis that climate patterns shaped the current distribution of the Gila monster in California. Precipitation is decidedly biphasic east of 116° longitude, with over 24 percent falling in the warm season. Warm season precipitation data from recording stations closest to Gila monster localities are almost identical for those in western Arizona where the species is more common. Summer precipitation may be important in the foraging ecology of the species. Gila monsters were probably already rare in California long before the arrival of Europeans due to changes in climate and landform that delimited the marginal location of California in the range of this species. Fortunately, most of the habitat for this species in California is protected or relatively free from human disturbance.

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Rare species present unique challenges to conservation efforts. Not only are rare and secretive species difficult to census, but different types of rarity expose species to different extinction processes and vulnerabilities (Meyers 1997). The Gila monster (*Heloderma suspectum*) is widely distributed in the southwestern United States and northwestern Mexico, especially in the Sonoran Desert (Stebbins 1985; Brown and Carmony 1991), but rare in California. The latitudinal distribution of the species extends from about 25–35° north latitude, a distance of over 1,000 km. Throughout this range the species occurs primarily in desert

scrub habitats (Beck, 2005; Beaman et al., 2006) but also occupies a variety of habitats including thorn scrub, riparian, xero-riparian, desert grassland, and oak woodland plant associations from near sea level to over 1,500 m elevation (Bogert and Martín del Campo 1956; Brown and Carmony 1991). Despite a wide distribution in the hot deserts of North America, records for the Mojave and Colorado Deserts (the latter a subdivision of the Sonoran Desert [Burk 1977]) of California have been rare, scattered and sporadic (Table 1). The Gila monster is protected in California as a species of Special Concern. Effective conservation of such a rare species requires an understanding of the factors that define its rarity, whether natural or anthropogenic.

The objectives of this paper are twofold. First, we consolidated and reviewed all known information on this species in California. Since the literature on Gila monster records in California is diffuse, dated, and often cited in obscure references and reports, summaries and previously unpublished details are also excerpted in the discussion below for the sake of completeness. Photographs of all known Gila monsters from California are included herein, most of which have never been published. Observations were considered to be credible based on any one or more of the following criteria: existence of a voucher specimen or photograph, publication of the record in a peer-reviewed journal, the veracity of the observer(s), or the fact that independent observers, familiar with an area, reported sightings in the same area as other credible records. We recognize that our criteria may not be acceptable to all. For example, based on the existence of a vouchered specimen from the same mountain range, and other sightings in the area, we consider the Green's Well record in Table 1 to be credible despite the fact that the author who reported it does not (Mitchell 1978).

Our second objective was to evaluate existing data to determine the critical factors influencing the distribution of this species in California.

#### History of Gila Monster Records for California

*Mojave River.*—Baird (1859) was the first to mention a specimen from the “Mohave river” in his publication listing the reptiles of the Pacific Railroad Survey. Since the Mojave River (about 200 km in length) lies entirely in San Bernardino County, California, the largest county in the United States, the exact provenance of the specimen is impossible to ascertain beyond what is given, an ambiguity not unlike others attributed to Baird (Montanucci, 2001). The specimen is almost certainly one catalogued in the National Museum of Natural History as USNM 228171 (Steve Gotte, pers. comm.) and is represented by a partial skull, hyoid and trachea, and a partial post-cranial skeleton. The locality data in the National Museum reflects Baird's designation with the spelling variant “Mojave River.”

The USNM mammal bone catalogue (where the specimen was originally catalogued as #4401) lists Caleb B.R. Kennerly as the collector and Amiel W. Whipple as the donor. Whipple was in charge the Pacific Railroad Surveys along the 35th parallel and Kennerly was his Surgeon/Naturalist. The specimen was most likely collected sometime in 1853–4 although it was not catalogued until 1861. Most of the specimens listed by Baird include USNM numbers that were assigned in mid-1858 (Steve Gotte, pers. comm.). Since the specimen was not catalogued until 1861, Baird listed no number, thus supporting the conclusion that this was the

Table 1. List of Gila monster records and locations in California. Geographic coordinates are given as available in the source, or estimated as latitude/longitude or township, range and section from desert maps supplied by the Bureau of Land Management.

County	Location	Date	Reference	Comments
Imperial	Imperial Dam on the Colorado River, 32° 52' 59" N; 114° 28' 1" W	1964	Funk (1966)	45 m
Inyo	Kingston Range, 5.5 km ENE Horse Thief Springs	5/4/1980	Ford (1981)	945 m
Riverside	Blythe airport Chuckwalla Valley, some 40.2 km NE of Desert Center	1948 "about 4/25/1943"	Woodson (1949) Tinkham (1971)	12.7 cm specimen Chuckwalla Valley (Granite Mountains?) 750–1,000 m? UTM 3865209N, 629493E (T10N, R13E, Sec 17 fide Brown, 1976)
San Bernardino	Vulcan Mine Road, Providence Mtns.	4/16/1968	De Lisle (1979)	9 specimens See text. 34.93° North, 115.53° West
	Providence Mountains Providence Mountains, Mitchell Caverns	1978–1982 ?	De Lisle (1983) Mitchell Caverns staff pers. comm.)	
	Cadiz Valley, near Iron Mountain Kingston Range, 1.4 km W Porcupine Tank	4/8/99 5/20/1980	<i>in litt.</i> Ford (1981)	T1N, R16E, Sec. 19 1,220 m
	Kingston Range, 2.6 km W Kingston Peak	6/3/1980	Ford (1981)	1,130 m
	Kingston Range	2/1981	Ford (1983)	Ron Lee, Nevada Department of Fish and Game
	Kingston Range East flank of Clark Mtn.	5/22/2006	Basey (pers. comm.)	Photo taken
	Clark Mtn., 4 km NW Green's Well (T17N, R13E, Sec 8 NW) 1,371 m	1962 1977	Bradley and Deacon (1966) Mitchell (1978)	R665 UNLV collection Reliability of record questioned by author
	Clark Mountain, Pachalka Spring Piute Creek (Ft. Piute), 45 km NW Needles (T12N, R18E, Sec. 24, NW ¼, NE ¼)	? 5/9/1982	<i>in litt.</i> Bicket (1982)	See text Photo in publication
County unknown	Mojave River Southern California	< 1861 < 1906	USNM 228171 CAS 172	

same animal reported in his 1859 paper. Leonhard Stejneger, former curator of the Division of Reptiles and Amphibians at the Smithsonian, was apparently unaware that the specimen existed when he published the results of the Death Valley Expedition (Stejneger 1893).

Bogert and Martín del Campo (1956) considered the Mojave River assignment of Baird to be in error, suggesting that “. . .the data may originally have been abbreviated as ‘Mojave R’ and intended to designate the [Fort] Mojave [Indian] R[eservation] (rather than ‘River’) in western Arizona, where cinctum is to be expected.” However, Baird (1859) clearly designated the river, not the reservation, as the collection locality.

The Southern Pacific railroad parallels the Mojave River along much of its course, from the river’s terminus at the Cronese Dry Lakes, in the heart of the Mojave Desert, to near its source, high in the San Bernardino Mountains. Along the Mojave River, the survey would have passed through or near the following mountain ranges: Soda Mountains, Cronese Mountains, Cady Mountains, Calico Mountains, Newberry Mountains, and various low hills and promontories, characterized by Mojave desert scrub vegetation (Vasek and Barbour 1977). None of these ranges greatly exceed about 1,000 m in elevation, and the valley bottoms are about 300–500 m. Historically, habitat along the Mojave River was characterized by dense riparian communities of cottonwood, willow, mesquite and other relict wetland species (Lovich and Meyer, 2002), not unlike the site where the Piute Springs specimen was observed (see below).

*Chuckwalla Valley.*—Tinkham (1971) reported that “*There are no authentic records to date for the Gila monster in California, nor is there ever likely to be now, since the drought years of the past two decades have been so severe that an examination of the shrubs in almost any location will reveal 50–75% of the desert shrub vegetation as dead or dying.*” His proclamation that the desert was dying from drought was in error, as was his oversight of earlier records of Gila monsters in California reported by Baird (1859), Woodson (1949), Funk (1966), and Bradley and Deacon (1966). His statement is further contradicted by his own admission that, “*There is however, some evidence that the Gila monster had been seen in California prior to 1945. The most likely places are those mountain ranges in the Searchlight, Nevada region.*” He then related a story based on notes he made from statements of a friend named Lyell Howell:

*“About April 25, 1943, while General Patton’s tank corps was on maneuvers in the northeastern section of a branch of Chuckwalla Valley, some 25 miles northeast of Desert Center, a Gila monster was brought into headquarters by some of the men. As Mr. Howell was well acquainted with the chuckwallas, his statement that this specimen was a Gila monster in typical yellow and black markings, is probably correct.”*

If the bearing and distance from Desert Center to the collection site is correct, it would be located somewhere in the Granite Mountains in Riverside County (T2S, R18E, Sec. 28), which border the Chuckwalla Valley, at an elevation of about 750–1,000 m. This part of the range is very dry, without springs or riparian areas, characterized by desert scrub species (e.g., *Larrea tridentata* and *Ambrosia dumosa*), wash woodlands dominated by ironwood (*Olneya tesota*), and rocky





Fig. 1. Ironwood wash woodland near Palen Pass, Riverside County, California. Granite Mountains are in the background. Photo by Jeff Lovich.

hillslopes (Figure 1). The Chuckwalla Valley ranges from 200–350 m at the base of the Granite Mountains.

The locality record was incorrectly reported by Jennings and Hayes (1994), as “15.5 km east of Desert Center in the Chuckwalla Mountains.” Similarly, De Lisle (1986) erroneously listed this specimen as “. . . in the Chuckwalla Mountains, 25 miles east of Desert Center. . .”

*The lower Colorado River.*—Woodson (1949) published the details of a newspaper account (without citing the newspaper or date), describing a Gila monster that was discovered “. . . near Blythe, a few miles west of the Colorado River on the California side.” Workers uncovered a 12.7 cm juvenile Gila monster while tearing down a building near an airport. In spite of this observation, Woodson did not believe that the species was indigenous to California and considered earlier sightings to be escaped pets or misidentified chuckwallas (*Sauromalus obesus*).

Another Gila monster was killed by a night watchman at Imperial Dam, on the California side of the Colorado River, in June, 1964. The specimen was apparently given to the Arizona Game and Fish Office in nearby Yuma, Arizona, but the final disposition of the specimen is not known (Funk 1966). This was one of several Gila monsters reported by Funk from near Yuma. Observations occurred at elevations 30–45 m above sea level. Vegetation is typical of lower elevations of the Colorado Desert subdivision of the Sonoran Desert, with sandy soils supporting creosote bush (*Larrea tridentata*), burrobush (*Ambrosia dumosa*), and *Ephedra* sp. in well-drained areas, and riparian plant species (*Pluchea sericea*, *Prosopis juliflora*, *Tamarix ramosissima*) near the many irrigation canals.

It is worth noting that the record on the California side of the Colorado River



Fig. 2. The Gila monster from the Providence Mountains, Vulcan Mine Road, 16 April, 1968, 1000 hr. Photo is catalogued as Los Angeles County Museum Photographic Catalog (LACMPC) #1331. Photo by Harold De Lisle.

is not the westernmost record of Gila monsters from this area (Funk, 1966). Due to the meandering course of the Colorado River, specimens from near Yuma, Arizona were found about 14.5 km west of the California record above.

*Providence Mountains.*—With elevations at over 2,000 m, the Providence Mountains are one of the southernmost in a series of Mojave Desert “sky islands” supporting relict populations of plants and animals that survived post-Ice Age changes in climate by retreating to more mesic and temperate climes on their slopes. Around 1000 hr on 6 April, 1968, a Gila monster was observed and photographed by De Lisle (1979) near the Vulcan Mine road on the west side of the mountains (Figures 2 and 3). Recognizing the significance of the find, the author captured the animal and gave it to the Los Angeles Zoo where it was displayed until its death in 1990. The specimen was subsequently donated to the Natural History Museum of Los Angeles County. A recent search of the museum collections failed to locate the specimen and it is presumed lost.

De Lisle discounted the possibility that the specimen was a released captive based on the remoteness of the area, the lack of extensive off-road use of the





Fig. 3. Same Gila monster in Figure 3 photographed while at the Los Angeles Zoo.

desert at that time, and the fact that the specimen was diagnostic of the geographically expected race, *H. suspectum cinctum*. Figures 2 and 3 clearly show the banded pattern typical of this subspecies. De Lisle (1986) indicated that specimens from the Providence Mountains were mostly pink with a reduction in black pigmentation relative to other *H. suspectum*.

Between 1968 and 1982 nine additional “specimens” were reported from the Providence Mountains (De Lisle 1983), but none were photographed or collected. Conversations with De Lisle indicate that not all were observed in 1982, and at least one may have been sighted in 1978 (De Lisle 1986). De Lisle considered the spate of sightings around 1982 to be attributable to “*some combination of climatic conditions favoring surface activity.*” Further details for the additional nine Providence Mountain “specimens” were not provided by De Lisle, and it is unknown whether the number reflects repeated sightings of an individual or individuals.

Additional Gila monsters may have been observed by state employees at Mitchell Caverns Natural Preserve in the Providence Mountains State Recreation Area, although some of those specimens could include records mentioned by De Lisle (1983; De Lisle, pers. comm.). This site is located on the eastern side of the range, opposite from where De Lisle reported his first specimen. Conversations with these observers indicate that most sightings occurred in May or June along the east side of the trail leading to the cave.

*Piute Mountains.*—On 9 May, 1982, a Gila monster was photographed (Figures 4 and 5) at Piute Creek (Fort Piute) in the Piute Mountains of San Bernardino County (Bicket 1982). Field notes indicate that the animal was seen at about 1330 hr and was approximately 35.6 cm in length (Bureau of Land Management, *in*





Fig. 4. The Gila monster from Piute Springs (see caption of Figure 3) in riparian streambed. Photo by Ann or Rachel Curren. LACMPC #1364c.

*litt.*). When observed, it was in a streambed among vegetation and surface litter. The temperature at the time was 18.3° C under sunny, mostly clear skies with winds of 8–16 kph. It had rained “several” days prior to the observation. The elevation at the site is 853 m. Piute Creek is the only perennial stream for many kilometers around and is characterized by typical desert riparian plant species including *Salix* sp., *Baccharis viminea*, *Prosopis* sp., and *Tamarix ramosissima*. A subsequent herpetological survey of the site did not detect Gila monsters (Hazard and Rotenberry 1996).

Brown (1976) reported that the owner of the YKL Ranch told BLM biologists in 1975 that “. . .there used to be gila monsters in the northern Piute Range in the vicinity of Stray Cow Well and Willis’ Hole. He and his personnel also reported seeing a gila monster along the Old Government Road near Fort Piute several decades ago.” Stray Cow Well is near the Nevada state line, and Willis’ Hole may refer to nearby Lewis Holes, just over the state line in Nevada.

It is worth noting that the pattern exhibited by the specimen in Figures 4 and 5 is more reticulate than photographs of other California Gila monsters in this paper. This pattern is more suggestive of *H. s. suspectum* than of the expected race *H. s. cinctum*.

*Kingston Range.*—In 1980, three separate sightings of Gila monsters occurred in the Kingston Range of the northeastern Mojave Desert of California during a survey of the natural resources in the area (Stone and Sumida 1983). The Kings-



Fig. 5. The Gila monster from Piute Springs (Fort Piute), San Bernardino County, California. Photo by Earl Curran. LACMPC #1364a.

tons are part of a chain of sky islands with elevations exceeding 2,200 m. The first specimen was sighted, and photographed (Figures 6 and 7), 5.5 km east-northeast of Horse Thief Springs (elevation 945 m) on 4 May, 1980, and is the only documented Gila monster from Inyo County. The second was sighted 1.4 km west of Porcupine Tanks at 1,220 m on 20 May, 1980. The third was seen 2.6 km west of Kingston Peak at 1,130 m on 3 June, 1980. All three occurred in sandy washes associated with large boulders. Plant species in the area included catclaw acacia (*Acacia greggii*), burrobush (*Ambrosia dumosa*), Death Valley ephedra (*Ephedra funerea*), creosote bush (*Larrea tridentata*), and desert almond (*Prunus fasciculata*) (Ford 1981).

A subsequent sighting in February, 1981 by Ron Lee (a Nevada Department of Wildlife technician) was reported by Ford (1983). Additional details of the sighting were not provided. Correspondence to one of the authors (KRB) contains testimony from a Mr. Junior Huffman who claims to have seen two Gila Monsters in the Kingston Range, one in the mid-1970's and the other in the early 1980's, on Furnace Creek Road between the Omega and Standard Slag Iron Mines.

Gila monsters continue to be reported in the Kingston Range. An individual was photographed by R. Terry Basey in a sandy wash in the northwest part of the range on 22 May, 2006, at 10:45 AM. Weather conditions were warm and sunny following the passing of a weak cold front through the area during the early hours of the previous day. That individual also exhibited a strongly banded pattern (Figure 8).





Fig. 6. Gila monster from the Kingston Range, San Bernardino County, California, 1.4 km west Porcupine Flats. Photo by Randall Ford, 30 May, 1980. LACMPC #1329.

*Clark Mountain.*—At almost 2,400 m, Clark Mountain is the highest of the east Mojave sky island mountain ranges in California. Bradley and Deacon (1966) reported a specimen collected from the eastern slope of the Clark Mountains in 1962 now in the collection of the Marjorie Barrick Museum of Natural History at the University of Nevada, Las Vegas (#R 665, Figure 9). The snout-vent length of the specimen is 267 mm with a total length of 40.5 cm. This collection site is about 11 km southwest of the California-Nevada state line. Several other specimens were reported from nearby Clark County, Nevada, and all were collected at elevations below 1219 m (Bradley and Deacon 1966).

Additional surveys of the Clark Mountain area were conducted by Mitchell (1978) who failed to find additional specimens. However, he interviewed a Mr. Smith who reported seeing a Gila monster in 1977 four km northwest of Green's Well, on the north side of the range, near a dirt road at 1,371 m elevation. The area is characterized by Joshua trees (*Yucca brevifolia*), some desert willows (*Chilopsis linearis*), and many boulders. It was the only Gila monster that Smith observed in 25 years of roaming the Clark Mountain area. Mitchell expressed some doubt concerning the reliability of the report since Mr. Smith could not remember the time of year when he saw the lizard. This is the same Gila monster record reported by De Lisle (1983) for the Clark Mountains (De Lisle, pers. comm.).

In correspondence to one of the authors (KRB) from Dan Guthrie, it was indicated that a Ms. Jan Smith (daughter of long time resident of the Curtis Mine, Mr. Frank Curtis) observed a Gila monster at Pachalka Spring on the west side of the Clark Mountains.

*Other sightings and records.*—Several other sightings of Gila monsters have



Fig. 7. Gila monster from the Kingston Range, San Bernardino County, California, 1.4 km west Porcupine Flats. Photo by Randall Ford, 30 May, 1980. LACMPC #1330.





Fig. 8. Gila monster from the Kingston Range, San Bernardino County, California. Details of the sighting will be reported elsewhere. Photo by R. Terry Basey, 22 May, 2006. LACMPC #1439.

been reported from California. Although many are unverified or unsubstantiated by photographs or voucher specimens, they are listed here to stimulate additional searches for this elusive species. Some of the records of Gila monsters in California are undoubtedly for released captives, like the two specimens listed from urban Contra Costa County by Bury and Luckenbach (1976), an area well outside of the natural historic range of the species. However, translocated specimens have turned up in remote portions of the California desert as well. According to Brown (1976), a specimen was reported from the OX Ranch, Lanfair Valley, San Bernardino County in June, 1975. Apparently, the animal was a captive brought from Arizona by a ranch hand. That specimen is now housed at Museum of Vertebrate Zoology, U.C. Berkeley (MVZ 128983), after reportedly being won in a card game by California herpetologist Roger Luckenbach (Harry Greene, *in litt.*).

On April 8, 1999, a Gila monster was seen in the Cadiz Valley of San Bernardino County near Iron Mountain (T1N, R16E, Sec. 19). The sighting occurred at 0730 hr on a dirt road as an archaeologist was working on a project in the

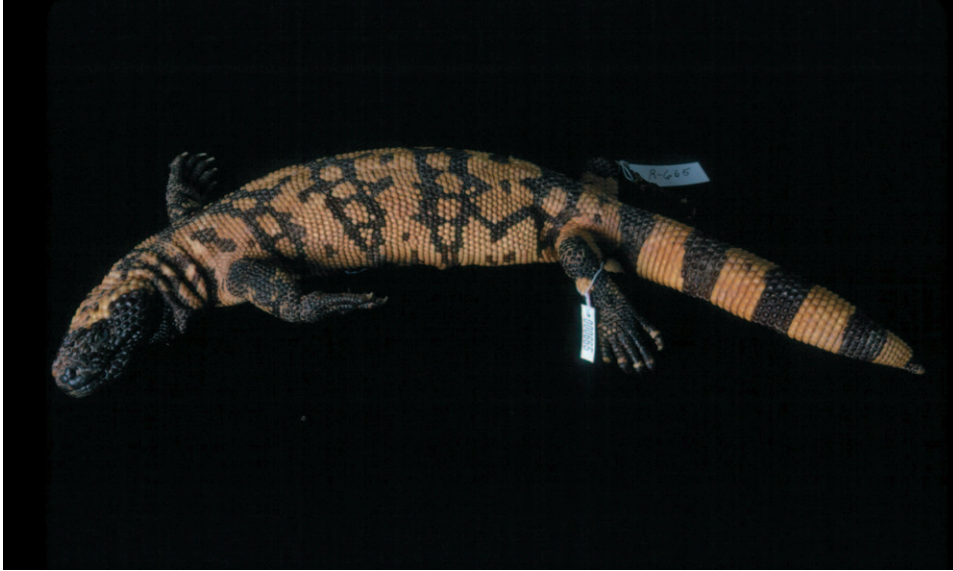


Fig. 9. Gila monster from Clark Mountain, San Bernardino County, California. Marjorie Barrick Museum of Natural History, University of Nevada, Las Vegas #R665.

area. The individual that discovered the animal was familiar with Gila monsters and was certain of the identity of the specimen. No photographs were taken. The relatively populated nature of the area to the west of this locale suggests the possibility that the specimen was a released captive. Furthermore, the area appears to be atypical of habitats where other Gila monsters have been observed in California (with the possible exception of the Colorado Desert records near Blythe and Desert Center), casting some doubt on the probability that it was indigenous.

Other Gila monsters have been reported from the area around Barstow, California, lending further credence to their occurrence along the Mojave River as discussed previously. In a letter to one of the authors (KRB), Steve Smith reported the following newspaper article published in the Barstow Printer Review on 5 June, 1958, page 9:

*Persistent reports that Gila monsters are invading California were lent a little more credence this past week by the shooting of a lizard closely resembling the description of the poisonous Gila of Arizona by Mrs. John Sturnacle of Barstow. Reports of Gila monsters recently on the slopes of Mt. General near Hinkley and through the Calicos, have been discounted in the past. The beaded lizard, believed to be the only poisonous lizard in the United States, has been considered to be a denizen of Arizona and never found in California. A second sighting of a large lizard with a blunt tail, and whose hide displayed a beaded appearance and was ringed with red and cream bands, took place in the sand hills north of Hinckley Sunday. The lizard hissed characteristically when disturbed, and scuttled off down a dry wash. The 17-inch lizard shot by Mrs. Sturnacle was exhibited at the meeting of Cub Scout pack 68 on May 28, and taken to school to show the second graders at Cameron. Mrs. Sturnacle was moved to shoot the reptile when her small son*



*chased it across the yard. He was deterred from picking the lizard up by his sister Deloris Ann, who is a second grade pupil at Cameron. The California Department of Fish and Game has been queried to determine the advisability of warning parents of small children to watch for the big lizards.*

One specimen, catalogued by the California Academy of Sciences as #172 from "southern California" was lost in the earthquake and fire of 1906. No other data are associated with this specimen.

It is important to consider possible misidentifications of other lizard species when evaluating Gila monster records in California. Some recent records have doubtless been chuckwallas (*S. obesus*), or other species, including exotics. The Yuma Sun reported sightings of a large lizard along the Colorado River in an article from the 29 June, 2001 edition. The animal was photographed and determined to be a water monitor (*Varanus salvator*). We are aware of savanna monitor (*V. exanthematicus*) sightings in the California desert as well (Lovich, pers. obs.).

### Discussion

That the Gila monster is a resident of California is now well-supported by as many as 26 records, from four counties, at no less than nine locations, during the last 153 years (Table 1). Additional support for their indigenous status is given by the fact that specimens for which good photographs or descriptions are available generally agree with the subspecies *Heloderma suspectum cinctum*, which is the race expected west of the Colorado River.

However, this conclusion was not reached without considerable disagreement and contradiction in the scientific literature. The earliest published record of Gila monsters in California we found was that of Baird (1859) for the Mojave River specimen described above. Cooper (1869) included the Gila monster in his list of species known from the desert region of California. In contrast, Van Denburgh (1897) only acknowledged the possibility they occurred in California in his statement that "*It may be that it occurs on portions of the deserts of southeastern California, but as yet no specimens from this area have found their way into museums.*"

Despite the lack of consensus, some of the earlier claims were no doubt repeated by other writers who included California in the range of the Gila monster (Vick 1902; Willey 1906; Douglas 1910). That was until 1949 when Woodson published his record from Blythe and concluded that the Gila monster was not indigenous to California. Even the famous California desert naturalist, Edmund Jaeger (1956), considered the Gila monster to be absent from the state's fauna because of a barrier effect from the Colorado River, and Bogert and Martín del Campo considered the Mojave River specimen in the Smithsonian (see above) as "doubtless in error". Stebbins (1954) did not include California in the range of the Gila monster until publication of the second edition of his well-known field guide (Stebbins 1985), and Tinkham (1971) doubted that there were authentic records for the state over 100 years after Baird's initial report. The uncertainty began to change in the 1970's and 1980's as additional sightings occurred and photographs were taken.

Almost everything we know about this species has been shrouded in mystery at one time or another (Brown and Carmony 1991), so it is no surprise that it

took so long for the Gila monster to be accepted as a part of the fauna of California. Due to the paucity of records, we have only a rudimentary understanding of the Gila monster's habitat requirements and ecology in California in particular, and the Mojave Desert in general. Seven out of the nine records in Table 1 with month of capture occur in April or May suggesting that this is an important time for surface activity. A May record from nearby Clark County, Nevada, is consistent with this finding (Cowles and Bogert 1936). Beck (1990) conducted detailed ecological studies on Gila monsters in the Mojave Desert of southwestern Utah and observed that 64 percent of Gila monster activity occurred from April–July. Although the records are scattered for this species in California, common habitat themes are worth noting. Most observations have occurred in mountainous areas with rocky, incised topography, in large and relatively high ranges. Many are associated with riparian areas, including the lower Colorado River. Most records occur at moderate elevations, but range from near sea level to over 1,200 m.

De Lisle (1983) suggested that some combination of weather patterns influences when Gila monsters are seen in California. Looking at the years of sightings in Table 1, only 1964 and 1977 were El Niño years. Of the other sightings, three (1962, 1968, and 1982) preceded El Niño years, and three (1943, 1948, and 1999) followed El Niño years. The years around 1982 are of interest because that was the time period that De Lisle (1983) reported nine sightings in the Providence Mountains. Local weather conditions may have been responsible. To test De Lisle's weather pattern hypothesis, we examined long-term (1958–1996) precipitation records (Hereford and Longpré 1999) for Mitchell Caverns, in the heart of the Providence Mountains. The year 1982 was in the middle of an exceptionally wet period that lasted from 1978–1984 (see also Hereford et al., 2006). During the time from 1982–1983 the local area experienced an unusually high number of days with precipitation over the course of a year, and warm season precipitation (defined by Hereford and Longpré as 1 July–14 October) was notably high from 1982–1984. The percentage of annual precipitation falling during the warm season from 1958–1996 has a mean of 29% (SD = 17.8%). From 1982–1984 the percentage exceeded 43% with 1982 being almost one standard deviation above the long term mean. The connection between El Niño years and environmental responses is not always straightforward (Bowers, 2005) and additional analyses are needed to determine their effect on Gila monster activity.

The geographic distribution of records suggests that the species is confined to the eastern portions of the California desert, despite the fact that visually similar habitats occur in the central and western Mojave Desert, as well as the Colorado Desert. Records from the Providence Mountains, Clark Mountains and Kingston Range suggest that Gila monsters may be a relict species isolated on the flanks of Mojave sky islands as the regional climate changed following the end of the last Ice Age. The locations of fossil helodermatids reveal a much wider distribution in the past during the Late Eocene of France, and the late Paleocene (and possibly late Cretaceous) to Recent of North America (Pregill et al. 1986).

Early in the Holocene Epoch (11,000–8,000 years ago) pluvial lakes occupied much of what is now the Mojave Desert because of sustained higher and more seasonal precipitation than what now characterizes the region. The Gila monster may have been widely distributed in the Mojave and Colorado Deserts around this time as Pleistocene (Rancholabrean) fossils are known from Gypsum Cave



in Clark County, Nevada (Brattstrom 1954), and a late Irvingtonian fossil of *Heloderma* spp. is known from Anza-Borrego Desert State Park (Gensler, 2001). Then, about 7,000 years ago, the climate became sharply dryer and hotter (Grayson 1993), and reliable summer precipitation became more confined to the eastern Mojave Desert. The range of Gila monsters in California may have expanded into areas with reliable summer precipitation, or contracted into them, depending on whether they were moving up from southern refugia in the Sonoran Desert, or had remained in the region during glacial periods of the Quaternary. Invasions northward out of the Sonoran Desert may have used the Colorado River riparian corridor to enter the Mojave Desert as suggested by Bradley and Deacon (1966). As the climate shifted toward hyper-xeric conditions (possibly exceeding modern conditions) in the late Holocene, Gila monsters were restricted to areas with significant summer precipitation, many of which occur at moderate elevations on large mountain ranges in the northeastern Mojave Desert. Thus, the current distribution of modern records for Gila monsters in California appears to reflect the remnants of a lower Colorado River invasion from the Sonoran Desert into topographical refugia in the northeastern Mojave Desert with climatic conditions suitable for the species.

Other reptile species that appear to be isolated as relict populations in the high ranges of the northeastern Mojave Desert (Stebbins 1995) include the ring-necked snake (*Diadophis punctatus*), western fence lizard (*Sceloporus occidentalis*), striped whipsnake (*Masticophis taeniatus*), Smith's black-headed snake (*Tantilla hobartsmithi*), Gilbert's skink (*Eumeces gilberti*), and Panamint alligator lizard (*Elgaria panamintina*). Relict mammal species in the northeastern Mojave sky islands include the gray wolf (*Canis lupus*), now extirpated (Schmidt 1991), and porcupine (*Erethizon dorsatum*) (Johnson et al. 1948).

The distribution of Gila monsters in California may be related to biphasic annual rainfall patterns (Beck 2005). The Sonoran Desert of Arizona, where the Gila monster is more common than elsewhere in the United States, is characterized by distinct periods of winter and summer rain. Mean summer precipitation accounts for 39.7% of the annual total for 16 locations in the western Arizona desert according to Rowlands (1995). The significance of summer precipitation in defining the climate space of the Gila monster was noted by Bogert and Martín del Campo (1956) who suggested that the perceived absence of Gila monsters in California was related to dry summers west of the Colorado River. Tinkham (1971) similarly noted the importance of summer rainfall in defining the range of the Gila monster, showing that the subspecies *H. s. cinctum* occupied a climate space with slightly more winter rainfall and lower temperatures relative to the nominate race. The need for summer and winter rainfall may be related to associated biphasic increases in bird and mammal prey abundance in the spring, and again after the onset of summer rains in southern Arizona and Sonora, Mexico (Brown and Carmony 1991). The small early August peak in seasonal activity observed by Beck (1990) for Gila monsters in southwestern Utah suggests that the species responds similarly in the Mojave Desert.

Rowlands (1995) summarized rainfall data from throughout the Mojave and Colorado Deserts of California. Plotting his data (Figure 10), after removing the high altitude record for the White Mountains, shows a strong correlation ( $R^2 = 0.812$ ,  $P < 0.001$ ) between longitude and the percentage of annual rainfall that

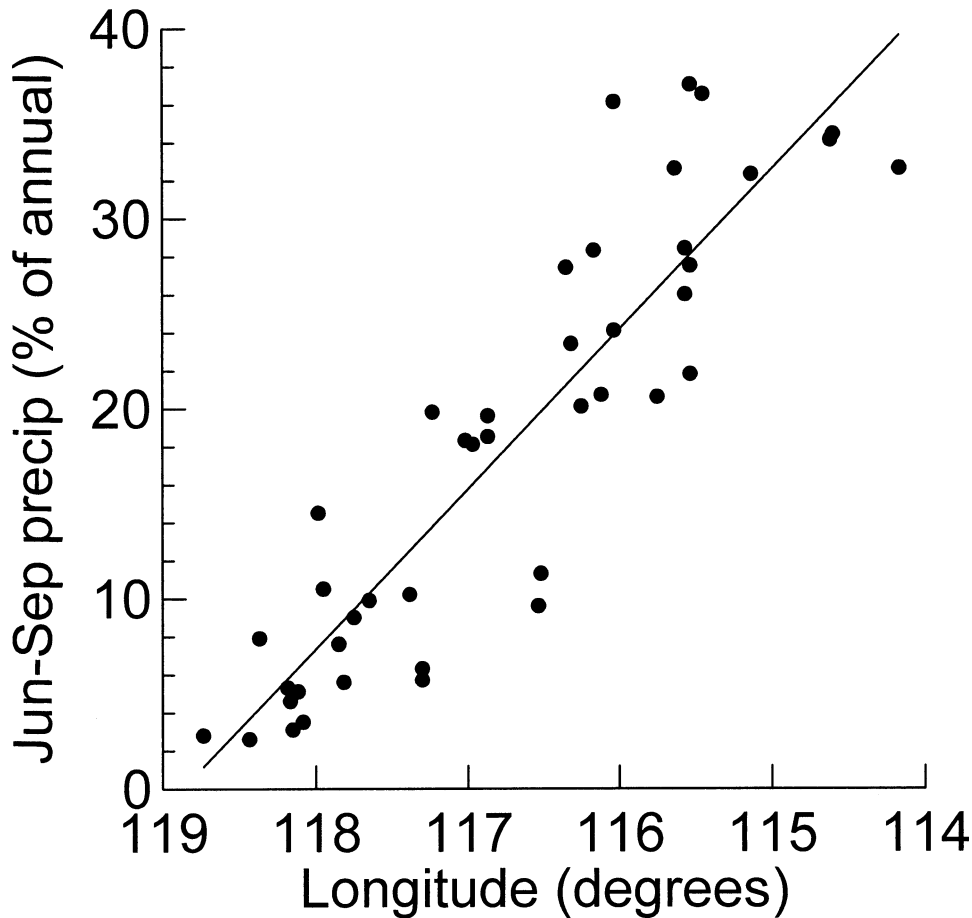


Fig. 10. The relationship between longitude (x-axis from west to east) and the percentage of annual rainfall occurring in the months from June–September in the Mojave and Colorado Deserts, California. From Rowlands (1995) but does not include the high altitude White Mountains record. Data are from the U.S. Department of Commerce, Weather Bureau (1945–75, 1952, 1958, 1964 [sic]).

occurs in the summer (defined by Rowlands as June–September). All known Gila monster records in California occur east of about  $116^{\circ}$  longitude, except for the specimen from the Mojave River. According to the relationship portrayed in Figure 10, this corresponds to areas receiving greater than 24% of the total annual precipitation between June and September. Using Rowland's data, and selecting the recording stations closest to the Gila monster records listed in Table 1 (Eagle Mountain – 36.5%, Imperial – 26%, Blythe – 34.4%, Iron Mountain – 32.3%, Mitchell Caverns – 27.5%, Mountain Pass – 37.0%, Needles – 34.1%) shows that the mean summer precipitation at these locales account for 32.5 percent of the annual total, which is close to the mean value of 39.7% for western Arizona reported above (Rowlands 1995). Beck (2005) reported that Gila monsters are “conspicuously absent” from areas where summer precipitation is less than 25% of annual precipitation, which fits our model of distribution in the Mojave Desert of California very well.

The absence of Gila monster records in other large mountain systems west of 116° longitude (San Bernardino, Little San Bernardino, Santa Rosa, San Jacinto, and Avawatz Mountains, and the Panamint and Coso Ranges, to name but a few) supports the presumed importance of summer rainfall to California Gila monsters, a finding that was echoed by Ford (1983). However, if this scenario is correct, why haven't Gila monsters been recorded from some sky islands east of 116° longitude such as the Granite Mountains adjacent to the Providence Mountains? The Granites and other significant mountain ranges east of 116° longitude in California (the Whipple Mountains, Turtle Mountains, and Chemehuevi Mountains) were suggested by Brown and Carmony (1991) as areas where surveys for this species should be intensified.

Conservation of the Gila monster in California requires an understanding of the factors defining its rarity along with the interaction of historical and climatic factors. It is likely that the Gila monster was rare in California long before the arrival of Europeans due to climatic changes and the marginal location of the state in the range of this species. The current restriction of the range to areas east of 116° longitude provides a focal area for conservation efforts. Fortunately, this part of California, often referred to as the "Lonesome Triangle," is still largely undisturbed (but see Lovich and Bainbridge 1999), and much of the Gila monster habitat therein is protected in designated wilderness areas or the Mojave National Preserve. However, the small population size of Gila monsters in California presents special challenges, including the Allee effect, loss of genetic diversity, and inbreeding (Meyers 1997), that are not easy to manage and increase the risk of local or regional extirpation. Recognition of these challenges will be required to maintain the elusive and enigmatic Gila monster as a viable part of California's exceptionally diverse biota (Meyers et al., 2000).

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