Comparison of Herpetofaunas of a Natural and Altered Riparian Ecosystem[1]

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Abstract.—Reptile abundance and diversity were greater on an unaltered riparian ecosystem than on an altered site; the former had some species typically found on upland habitats (e.g., chaparral) and the latter was comprised of species from adjacent Sonoran Desert. The distribution and abundance of certain microhabitats appear to account for differences in reptile abundance and diversity on the two sites.

Over the past 25 years, concerns have increased about the impacts of population growth and associated development on wildlife habitats within the southwestern United States, especially the impacts of increased demand for water resources within arid regions. A series of long-term studies on the Colorado River have shown that dam-induced habitat alternations have reduced overall bird abundance and diversity (Ohmart et. al. 1977). Most of the once widespread riparian woodland along the Colorado River has been replaced by non-native salt cedar (*Tamarix* spp.) and shrubs typically found in intermittent drainages (Ohmart et. al. 1977). Many of the birds requiring riparian woodland are no longer found along the Colorado River.

Many studies demonstrate how water impoundments impact birds and fish of riparian and aquatic habitats, but little is known about impacts on amphibians and reptiles inhabiting these ecosystems. Jones et al. (1985) and Jones and Glinski (1985) found that a number of mesic-adapted or upland amphibians and reptiles were restricted entirely to cottonwood-willow riparian habitats within the Sonoran Desert. Usually found in habitats of the Upper Sonoran Life-zone (e.g., Chaparral), these species immigrated into lower elevations (< 762 m) of the Sonoran Desert via riparian corridors (Jones et al. 1985). Upland species occur on a few riparian sites within the Sonoran Desert that have maintained mesic habitat conditions (Jones et al. 1985). These conditions persist on these sites due to the moderating effects of leaf litter and logs resulting from cottonwood trees *(Populus fremonti)*, perennial waterflow, shading of the surface by trees, and accumulation of large debris piles resulting from periodic flooding (Jones and Glinski 1985). In California, for example, riparian ecosystems provide habitat for 83 percent of the amphibians and 40 percent of the reptiles known from that state (Brode and Bury 1984).

Water impoundment structures eliminate periodic flooding and significantly reduce stands of cottonwoods and willows *(Salix goodingii)* along major drainages (Ohmart et al. 1977). These structures may, therefore, significantly reduce mesic conditions in downstream riparian ecosystems. To determine the possible impact of impoundment structures on the herpetofauna of a desert riparian ecosystem, I studied two low elevation (< 762 m) sites, one with major water impoundments and one without any impoundments.

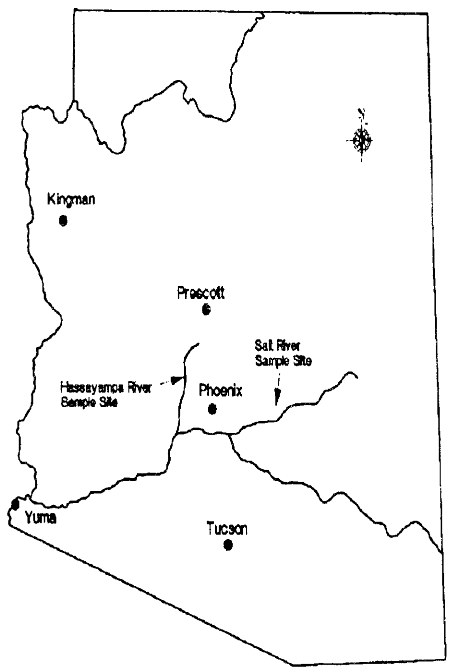

Figure 1.—Locations of the study areas.

Methods

To compare herpetofaunas of an unaltered vs altered desert riparian ecosystem, I chose study sites on the Hassayampa and Salt Rivers. The Hassayampa River has no major water impoundments. It originates in the Bradshaw Mountains 160 km north-northwest of Phoenix, Arizona, eventually draining into the Gila River approximately 80 km southwest of Phoenix. Lower reaches are mostly intermittent, except for a 15 km perennial section near Wick-

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enburg, Arizona. The study site was located approximately 10 km south of Wickenburg near Palm Lake, a former resort now owned by The Nature Conservancy, in a mature gallery-type stand of cottonwood *(Populus fremonti)* and willow *(Salix goodingii)* (elevation ca. 585 m, fig. 1).

The Salt River originates in east-central Arizona, flowing southwest to Granite Reef Dam (approximately 40 km northeast of Phoenix) where water is diverted for irrigation. Below this point, the floodplain traverses Phoenix, eventually draining into the Gila River approximately 26 km southwest of Phoenix. Historically, this river flowed perennially over its entire course. However, several major water impoundments, including dams forming Roosevelt, Apache, Canyon, and Saguaro lakes, have significantly altered flows and consequently physical characteristics. Flows are regulated by water releases at dams and flooding has nearly been eliminated; significant flooding has occurred only when water releases from lakes have been necessary. Before water impoundment, riparian vegetation was mostly cottonwood and willow, with mesquite *(Prosopis glanulosa)* occurring primarily on vegas adjacent to the river(Reference?). Mesquite and tamarisk now dominate the riparian community, with only a few small (< 100 m in length) sections of cottonwood and willow. The Salt River sample site was at Blue Point, located approximately 6 km south of Saguaro Lake (fig. 1). Cottonwood, willow, and mesquite trees were common at this site, although cottonwoods and willows were not nearly as common as on the Hassayampa River. Blue Point's tree gallery was poorly developed and I found no evidence of tree reproduction. Substrate was dominated by sand, with gravel bars located intermittently throughout the site. Similar to the Hassayampa River site, several small drainages traversed this site.

Table 1.—List of microhabitats measured at or around each pit-fall trap on each river. Frequency equals the percentage of quarters around each trap that had a certain microhabitat.

Soil type (at trap)	Rock width
Vertical cover (over trap)	Rock frequency
Distance to leaf litter	Distance to tree
Leaf litter depth	Tree height
Leaf litter frequency	Tree width (crown)
Distance to log	Tree frequency by species
Log diameter	Distance to shrub
Log frequency	Shrub height
Distance to debris heap	Shrub width (crown)
Debris heap width	Shrub frequency
Debris heap depth	Distance to grass Patch
Debris heap frequency	Grass height
Distance to rock	Grass frequency

The herpetofauna on each site was sampled by using a pit-fall trapping grid consisting of 110, double-deep 1.4 kg coffee cans placed 15 m apart in a 22 x 5 grid trapping configuration (1.9 ha) (see Jones 1987). Covers were placed approximately 15 cm above each trap to reduce loss of animals due to desiccation and exposure. Traps were open continuously between March and October, 1984. Traps were checked every three days, and amphibians and reptiles captured in traps were measured (snout-vent length, SVL), weighed, sexed, uniquely marked, and released into cover nearest to the capture site.

While traveling between pit-fall traps, I recorded observations of all frogs, toads, lizards, and snakes. I also flipped rocks and logs to uncover hidden herpetofauna.

In order to determine amphibian and reptile composition in adjacent Sonoran Desert, a modified array pit-fall trapping method was used (Jones 1987). Five arrays were placed in Sonoran Desert habitat adjacent to each site, and I checked these arrays for animals whenever I checked the main grids.

A point-center quarter (plotless) sampling method (Muller-Dumbois and Ellenberg 1974) provided data to characterize microhabitats around each trap. Each trap was a center point for quantifying density and frequency of microhabitats within 7m of each trap. I sampled 110 points or 440 quarters on each site. Microhabitat frequency was determined by dividing the number of quarters that a microhabitat occurred in (7 m or less from the trap) by the total number of quarters (440). I also estimated size (width, height, and depth) of each microhabitat and frequency of canopy cover as the percentage of pitfall traps that were covered by vegetation (table 1).

Relative abundance equaled the number of an individual species trapped during a 24-hour period. I estimated the diversity of herpetofaunas and microhabitats on each site using a modified Shannon-Weaver diversity index (H') (Hair 1980): $H' = \hat{E}P_i(\log_{10} p_i)$, where s = number of species and p_i = the proportion of the total number of individuals consisting of the i_{th} species. I used a Student's t-test to determine differences between herpetofaunas and microhabitats on the two sites. Finally, I compared herpetofaunas of the two riparian sites and adjacent Sonoran Desert by calculating Jaccard Similarity Coefficients and then clustered them using an unweighted pair group average (Pimental 1979).

Results

Microhabitats

The Hassayampa River had greater amounts and diversity of microhabitats than the Salt River (table 2). Of these differences, the frequency of downed litter on the two sites was the greatest (table 2). Leaf litter was 3 times more common, debris heaps 10 times more common, and logs and limbs twice as common on the Hassayampa River than on the Salt River (table 2). Rock substrate and grasses were more common on the Hassayampa River and shrubs on the Salt River (table 2). Trees were common on the Hassayampa River and sand substrate on the Salt River, although neither of these differences were significant (table 2). In addition, average leaf litter depth was significantly greater on the Hassayampa River than on the Salt River (table 2).

Of the specific types of canopy covering pit-fall traps, trees were by far the most common on both rivers, although the Salt River had more pitfall traps with no canopy cover (fig. 2).

Tree composition varied considerably between sites. The Hassayampa River had more cottonwoods *(Populus fremonti)* and willows *(Salix goodingi)* and the Salt River more salt cedars (*Tamarix* spp.) (fig. 3). Mesquite *(Prosopis glandulosa)* was the most common tree on both sites (fig. 3).

The Hassayampa River had more trees in the 0-1.9, 5.0-9.9, and 10.0-14.9 m height ranges, but most at the Salt River were in the 2.0-4.9 m range (fig. 4). Cottonwood height distribution was relatively even on the Hassayampa River, but most Salt River cottonwoods were greater than 10 m, with none less than 5 m, hence no reproduction (fig. 5).

Herpetofaunas

The abundance and diversity of herpetofauna was greater on the Hassayampa River than on the Salt River. The Hassayampa River had nearly twice as many species, more than twice the number of individuals, and a greater species diversity (1.05 vs. 0.86) than the Salt River (fig. 6).

All but three species *(Bufo microscaphus* x *woodhousei, B. punctatus,* and *Cnemidophorus tigris)* were more abundant on the Hassayampa River, and this site had five "upland" species *(Cophosaurus texanum, Diadophis punctatus, Eumeces gilberti, Masticophis bilineatus,* and *Tantilla hobartsmithii)* usually found in habitats of the Upper Sonoran Life-zone (e.g., chaparral). These upland species were absent from the Salt River and adjacent Sonoran Desert (table 3). *C. tigris* had the same abundance on both rivers, *C. tigris* was the most abundant species on the Salt River, and *E. gilberti* was the most abundant species on the Hassayampa River (table 3). The Hassayampa River also had 4 species with abundances greater than 1.0, whereas the Salt River only had one (table 3).

A cluster analysis of Jaccard Similarity Coefficients using data in table 3 revealed that the Salt River riparian site had a herpetofauna more similar

Table 2.—Comparison of microhabitat abundance between the Salt and Hassayampa Rivers. Abundance is the mean number quarters in which a microhabitat was found around each trap (within 7 m) ± SD.

Microhabitat	Salt River	Hassayampa River	Significant Difference ($p < .05$)
Rocks	0.5±0.4 (55)	1.9±0.7 (209)	Yes
Sand substrate	3.8±0.2 (418)	3.0±0.5 (326)	Yes
Leaf litter	0.9±0.5 (99)	3.7±0.8 (407)	Yes
Logs/downed tree limbs	1.5±0.7 (165)	3.8±0.2 (422)	Yes
Debris heaps	0.2±0.2 (18)	1.1±0.3 (123)	Yes
Trees	1.9±0.7 (213)	2.9±0.6 (315)	No
Shrubs	2.7±1.3 (297)	2.5±1.1 (275)	No
Grass	0.4±0.3 (48)	1.2±0.4 (128)	Yes
Microhabitat diversity (H')	.77	.87	

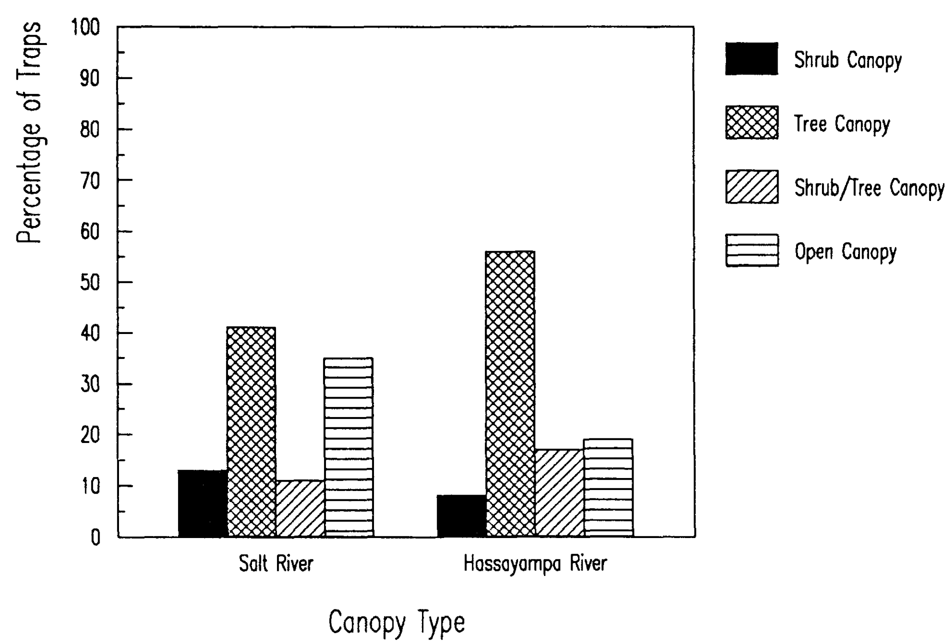

Figure 2.—Comparison of canopy types on the Salt and Hassayampa Rivers.

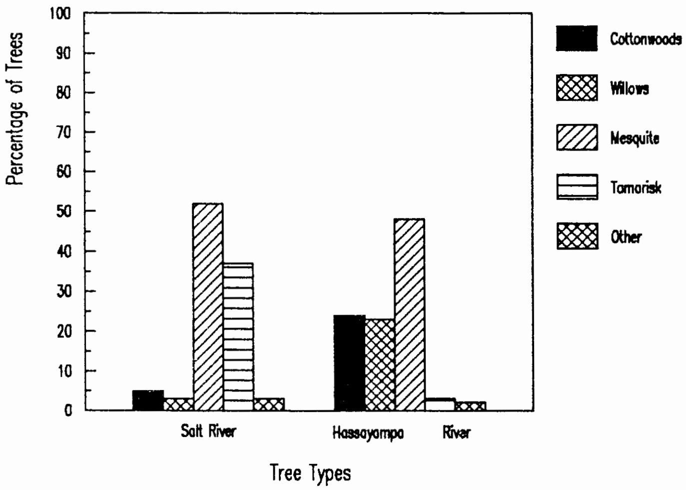

Figure 3.—Comparison of tree composition on the Salt and Hassayampa Rivers.

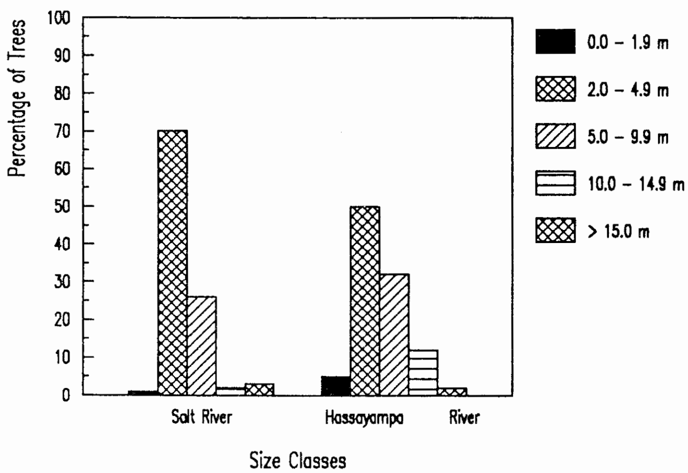

Figure 4.—Comparison of tree height distribution on the Salt and

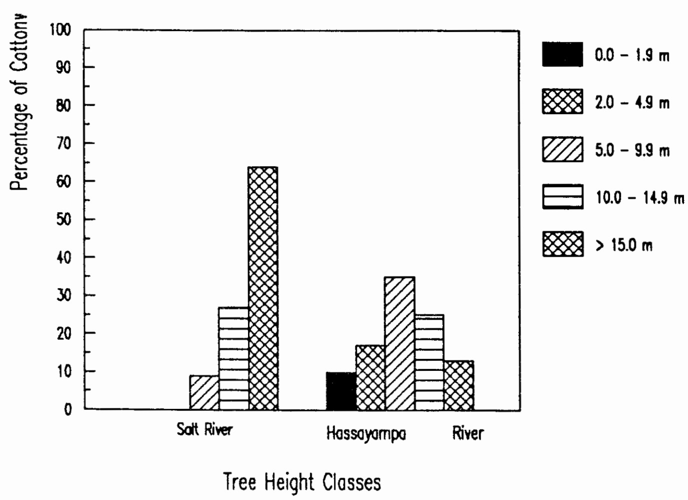

Figure 5.—Comparison of size classes of cottonwoods on the Salt and Hassayampa Rivers.

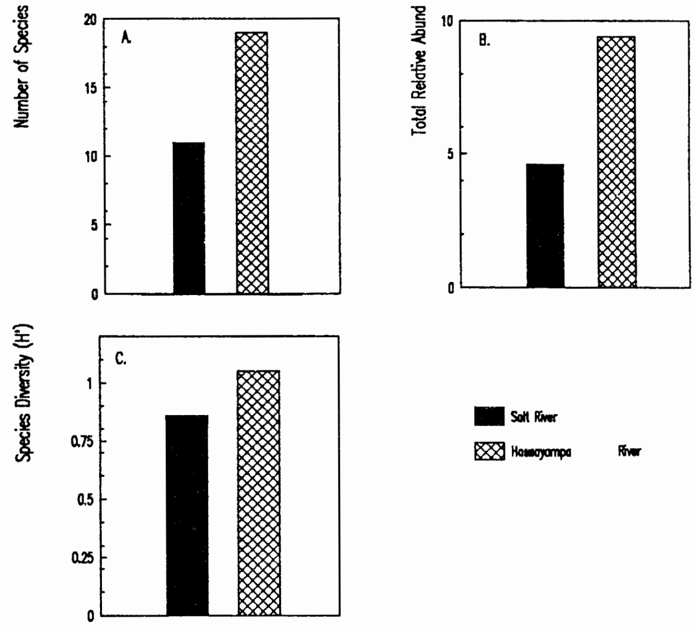

Figure 6.—Comparison of the total number of amphibians and reptiles, total relative abundance, and species diversity on the Salt and Hassayampa Rivers.

Table 3.—Comparison of lizard abundance and diversity between the Salt vs. Hassayampa River. Abundance is the number of lizards caught/grid/24 hours. Amphibians and reptiles occupying adjacent Sonoran Desert habitats also are indicated.

Species	Salt River	Hassayampa River	Sonoran Desert
Callisaurus draconoides	0.27	0.60*	X
Cnemidophorus tigris	1.47	1.47	X
Coleonyx variegatus	0.03	0.03	X
Leptotyphlops humilis	0.07	0.23*	—
Sceloporus magister	0.47	1.27*	X
Thamnophis cyrtopsis	0.07	0.10	—
Urosaurus ornatus	0.67	1.10*	X
Uta stansburiana	0.07	0.17*	X
Bufo microscaphus x woodhousei	0.40*	0.23	—
Bufo punctatus	0.57	0.40	X
Scaphiopus couchi	0.50	0.63	X
Cophosaurus texanum	—	0.20*	—
Diadophis punctatus	—	0.10*	—
Eumeces gilberti	—	2.17*	—
Lampropeltis getulus	XX	0.07*	X
Masticophis bilineatus	—	0.07*	—
Sonora semiannulata	—	0.10*	X
Tantilla hobartsmithii	—	0.37*	—
Bufo alvarius	—	0.23*	—

**Significantly greater abundance at p < .05.*

X Verified in adjacent Sonoran Desert habitats via pitfall trapping.

XX Verified on the Salt River site via field search.

to adjacent Sonoran Desert than to the herpetofauna of the Hassayampa River riparian site, although the two riparian herpetofaunas were relatively similar (fig. 7).

Discussion

The distribution, abundance, and diversity of herpetofauna on the Salt River correlate with impoundment-induced changes in microhabitats. On the unaltered riparian ecosystem on the Hassayampa River, many microhabitats were more abundant and diverse than on the Salt River, especially surface litter and trees. These differences in microhabitats correlate with differences in species diversity and abundance on the two rivers. Species that were most abundant on the Hassayampa River *(Eumeces gilberti, Sceloporus magister,* and *Urosaurus ornatus)* prefer sites with downed vegetative litter and vertical structure (e.g., trees) (Jones and Glinski 1985, Jones 1986). These reptiles were not nearly as common on the Salt River and this may result from lower surface litter and vegetation structure (higher percentage of salt cedar, *Tamarix* spp., and a lower percentage of cottonwoods, *Populus fremonti*, and willows, *Salix goodingii*) on this site.

The greatest difference between herpetofaunas on the two rivers was presence of five upland species on the Hassayampa River and the absence of these species on the Salt River. Jones and Glinski (1985) suggested these species occur in riparian habitats within low elevation Sonoran Desert because of the moderating effects of certain microhabitats, especially surface litter and debris heaps. Surface litter and debris heaps are considerably less common on the Salt River, and this probably accounts for the lack of any upland species in this river's herpetofauna. Szaro et al. (1985) suggest that debris heaps are the principal source of food and cover for *Thamnophis elegans*, and that grazing-caused reduction in this microhabitat caused decline of this snake in a high elevation riparian community.

The relatively low amounts of surface litter and lack of smaller size classes of trees (especially cottonwoods and willows) on the Salt River appear to result from dam-induced changes in water flow and flooding. Periodic flooding is essential in the long-term maintenance of southwestern U.S. riparian ecosystems (Brady et al. 1985). Flooding also provides the physical mechanism by which large debris piles are built (Jones and Glinski 1985). Water impoundment structures on the Salt River appear to prevent flooding regimes necessary to maintain cottonwood reproduction and debris piles.

Over the past 10 years, the major emphasis in riparian management has been to manage trees, particularly cottonwoods. Several techniques, such as planting live trees and tree poles, have been used on drainages with major water impoundment structures to improve reproduction and survival of cottonwoods (Swenson and Mullins 1985). Although these techniques generally increase nesting habitat for birds, they do not provide enough surface litter to support litter-dwelling species, such as upland herpetofauna. Szaro and Belfit (1986) studied a artificially created stand of riparian vegetation on Queen Creek in south-central Arizona. This stand of mostly willows resulted from accumulation of water behind a dike. Although the stand emulated vegetation structure of natural riparian sites, it had a depauperate herpetofauna, even after 20 years.

This study suggests surface litter is important in determining abundance and diversity of herpetofaunas in riparian communities. If we are to conserve riparian ecosystems, we must increase our emphasis on protecting all habitat components, including microhabitats such as surface litter. Like the Salt River site, riparian areas will loose litter-dwelling and

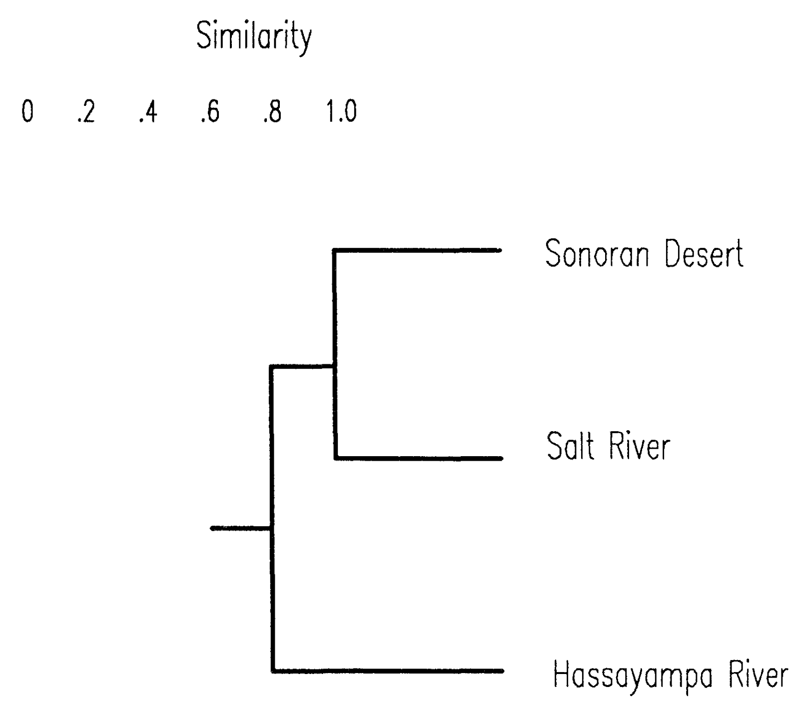

Figure 7.—Dendrogram comparing herpetofaunas of the Sonoran Desert and Salt and Hassayampa Rivers.

mesic-adapted species unless we consider these other components.

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