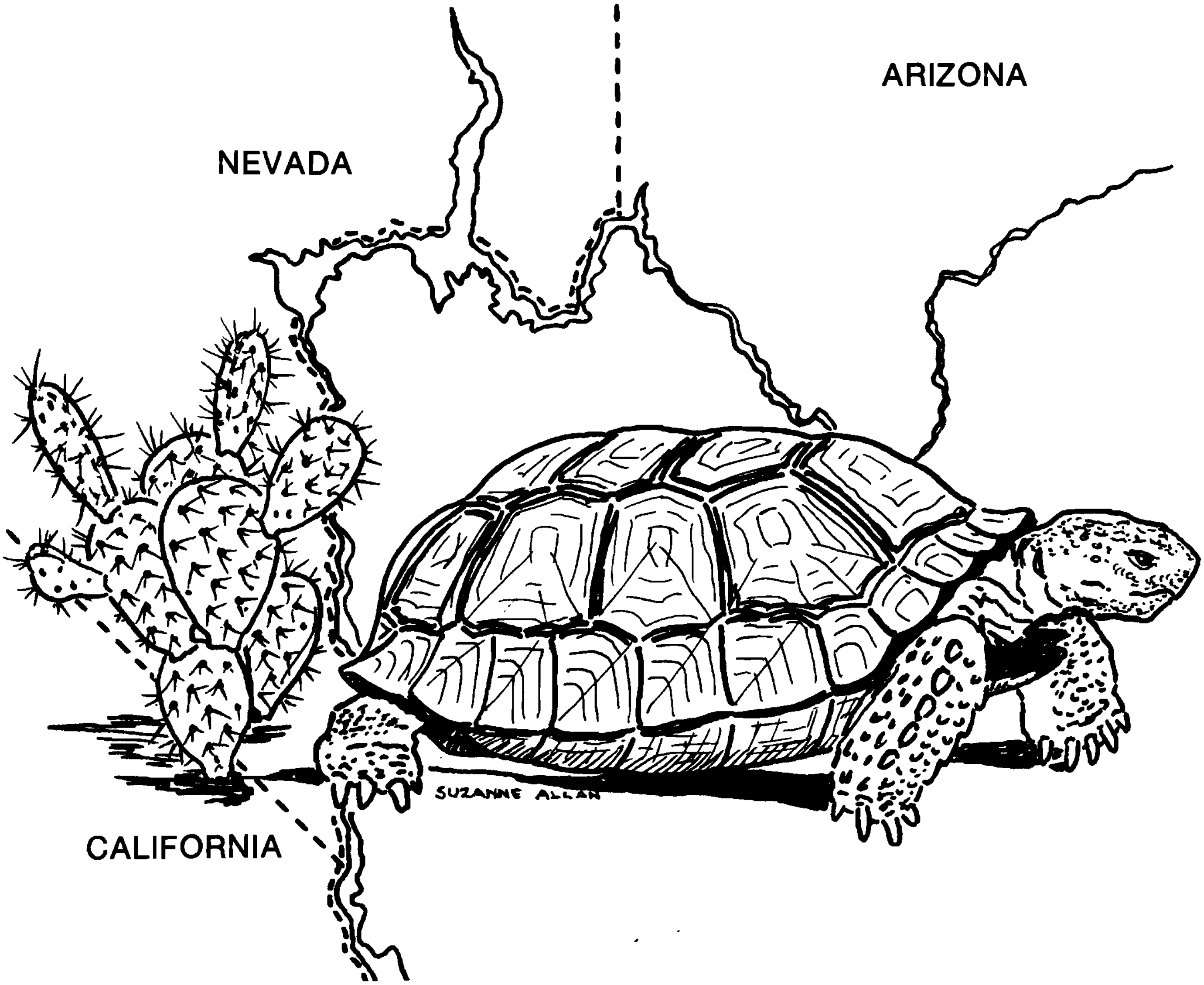
THE DESERT TORTOISE COUNCIL



PROCEEDINGS OF 1976 SYMPOSIUM

DESERT TORTOISE COUNCIL

PROCEEDINGS OF 1976 SYMPOSIUM

A compilation of reports and papers presented at the first annual symposium of the Desert Tortoise Council, March 23-24, 1976, in Las Vegas, Nevada

Copies of these proceedings may be obtained by sending $5.00 to: Desert Tortoise Council, 350 Golden Shore, Long Beach, CA 90802. Make check payable to Desert Tortoise Council.

Acknowledgement

The Desert Tortoise Council is indebted to the Southern California Edison Company for the printing of these Proceedings.

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<u>Desert Tortoise Council</u>

Jim St. Amant and Dr. Ross Hardy (Right) at the Showboat.

The Desert Tortoise Council - A Review, 1974-1976

James A. St. Amant

The Desert Tortoise Council was originally formed as an interim Recovery Team, which was created when members of the Prohibited and Protected Fishes, Amphibians and Reptiles Committee, a committee of the seven states' Colorado River Wildlife Council, found the desert tortoise, *Gopherus agassizi*, needed a helping hand in the four states where it is endemic. At that time Chuck Marshall, California Department of Fish and Game biologist assigned to the Colorado River, was selected as the Team leader. The first meeting, held in a Las Vegas hotel room, finally adjourning in the early morning hours, arrived at a number of basic needs. These included:

1. Very little was actually known regarding the status of wild desert tortoise populations.

2. Information on diseases of reptiles, particularly of desert tortoises, was almost non-existent.

3. Existing state regulations to provide protection to the desert tortoise were not adequate and the public was generally unaware of existing laws.

4. Coordination of work on the desert tortoise was badly needed. This includes improved communications between various state and federal agencies and schools.

5. Facilities were needed to handle unwanted captive tortoises prior to reintroduction to the wild.

Since the desert tortoise was not listed as a rare, threatened or endangered species, assistance through the Rare and Endangered Species Act was not available. Also, the Team felt that the desert tortoise had more interested friends than could be accommodated in a recovery team. Consequently, on April 21, 1975 the Desert Tortoise Council was born, committed to the goal of assuring the continued survival of viable populations of the desert tortoise throughout its existing range. Chuck Marshall continued as the leader, being selected as the first Chairman of the Council. Since that time the Council has grown to include membership of federal and state biologists, turtle and tortoise club societies, students, teachers, professors, zoo curators and people who are just interested in helping the desert tortoise.

Chuck, due to a new job and location assignment, had to resign as Chairman. Co-chairpersons were selected. Dr. Kristen Berry, Bureau of Land Management and Jim St. Amant, California Department of Fish and Game. Dr. Glenn Stewart, California Polytechnic University was selected as Chairman Elect and Tilly Barling, China Lake Naval Weapons Station, Secretary/Treasurer. Mary Trotter later became Secretary/Treasurer. Committee Chairmen were appointed and the bylaws approved.

To reach the Council's goal, seven main objectives were agreed upon by the members:

1. To serve in a professional advisory manner, where appropriate, on matters involving management, conservation and protection of desert tortoises.

2. To support such measures as shall work to insure the continued survival of desert tortoises and the maintenance of their habitat in a natural state.

3. To stimulate and encourage studies on the status and on all phases of life history, biology, physiology, management and protection of desert tortoises, including studies of native and exotic species that may affect desert tortoise populations.

4. To provide a clearinghouse of information among all agencies, organizations and individuals engaged in work on desert tortoises.

5. To disseminate current information by publishing proceedings and transactions of meetings and other papers as deemed useful.

6. To maintain an active public information and conservation education program.

7. To commend outstanding action and dedication by individuals and organizations fostering the objectives of the Council.

On March 23, 24, 1976 the first annual Desert Tortoise Council Symposium was held.

The Council has accomplished a number of significant achievements in the brief time it has been active.

Studies and surveys of wild populations have been undertaken.

A study of respiratory diseases in captive tortoises has been completed (see Dr. Murray Fowler's report).

An educational slide presentation was developed (with Bureau of Land Management funding) to be made available to schools and interested organizations.

Facilities were developed to handle unwanted captive tortoises in California for eventual release to the wild (see California State report).

Recommendations regarding classifying Utah's severely declining Beaver Slope tortoise population as endangered were provided (see Glenn Stewart's report).

Assistance has been given, on request, to agencies concerning regulations, handling of captive tortoises and recommendations for studies.

The Desert Tortoise Natural Area Committee was given the Council's first annual award for its successful efforts in protecting an important desert tortoise area.

In the past two years, meetings have been held in the four desert tortoise states to work on specific problems and coordinate work on the tortoise.

Coordination of the interest and work with the tortoise was demonstrated in the great success of the first annual Desert Tortoise Council Symposium. These Proceedings illustrate the interest that prevailed throughout the Symposium.

The second annual Desert Tortoise Council Symposium will be held March 24-26, 1977 in Las Vegas at the Show Boat. See you there.

California Department of Fish and Game
350 Golden Shore
Long Beach, California 90802

State Report - Arizona

Don Siebert
Bureau of Land Management

Preliminary inventories have begun on the tortoise population in the Arizona strip.

Surveys and studies are being conducted on the population in the Sierra Estrella Mountains in association with the proposed Montezuma Project (a pumped storage hydro generation project on the Gila Indian Reservation and proposed by Salt River Project).

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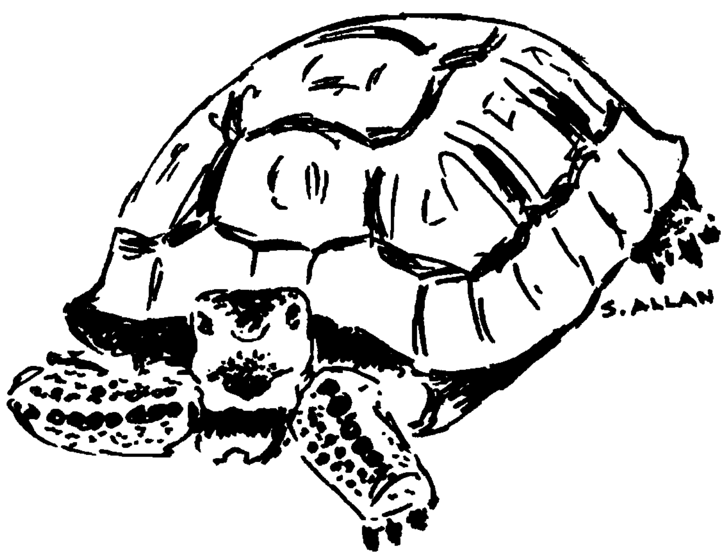

State Report - California

James A. St. Amant
Department of Fish and Game

In 1973 an important step was made in protecting the state's official reptile. At that time a law was passed making it unlawful to sell, purchase, harm, take, possess, transport or shoot any projectile at a tortoise. However, legally acquired tortoises can be possessed by a permit from the Department. The intent of this regulation was to stop the collecting of these animals from the wild. Included in this permit system is the tagging of each tortoise legally possessed. To date, 4,406 permits have been issued.

Actually, this represents about 4,200 tortoises, since some have changed hands. The only complaint regarding the system is that a few of the tags have worn through, obliterating the numbers.

Besides minimizing the collecting and sale of the tortoises, the permit system should eventually provide us with a good inventory of the captive tortoise population. We believe there are still a lot of people with tortoises in their possession who have not applied for permits.

As a result of news releases and enforcement of the new regulation, a number of captive tortoises have been turned in to the Department. This originally presented somewhat of a dilemma, since studies of captive tortoises released back to the wild demonstrated low survival. This was believed due mainly to the animal having been domesticated, therefore not prepared to survive in the harsh desert environment. The potential of introducing diseased tortoises to wild populations and upsetting existing social structures was also another major consideration for not releasing captives.

Many of the tortoises were provided to zoos in various states. (Karen Sausman, Living Desert Museum, deserves a great deal of credit for her efforts in contacting the zoos across the nation.) However, the supply was too great for the demand and another more permanent solution was called for.

As a result, we have the Halfway House. This consists of a fenced-in area at Fort Soda where the tortoises are held for one year for conditioning prior to release back to the wild. The conditioning consists of surviving in a desert area with a minimum of human association. Each animal is weighed, measured and given a number prior to release at the Halfway House, and records are kept of each animal's activity. Human contact is limited to once a week or every two weeks to bring food during the period of the year when the tortoises are active. The first tortoises were released at the Halfway House in June of 1975. As the program develops, we should be able to hold 100 to 200 tortoises for one year at a time which we can then release into suitable areas. Suitable areas are those that once supported tortoise populations that have been extirpated due to illegal collecting or habitat destruction and are now again able to provide adequate habitat.

Before releasing any tortoises we still must be assured they are free of communicable diseases. Hopefully, we will soon have techniques which will enable us to determine if a tortoise is healthy. The system now being developed for handling captive tortoises for rehabilitation back to the wild (which may eventually include captive hatchlings) will be holding the animals at the Living Desert Preserve at Palm Desert for examination and medical treatment when needed. Bob Claybrook is now working on this part of the program. When they are cured, they will then be taken to the Halfway House.

Fortunately, we have people like Bob Claybrook interested in helping us help the tortoises. Two others who have been very active in helping us with the captive tortoise problem are Mary Ann Lewis of the Westchester Turtle and Tortoise Club and Vern Kirchman of the San Diego Turtle and Tortoise Society. Mary Ann has been very active in finding homes for pet tortoises that are no longer wanted by their owners and also in finding homes for hatchlings. Mary Ann found homes for 222 desert tortoises in 1975. Vern Kirchman has been very helpful in treating and developing treatment techniques for diseased tortoises that have been turned in to the Department.

For any program of this type to be successful, public support is necessary. Ralph Young, our Information Officer for Region 5, has been very effective in publicizing the desert tortoise program through his almost brilliant news releases. A number of newspapers have used his releases, which have covered the permit system, the Halfway House, Maximus (believed to be the largest living desert tortoise, *Gopherus agassizi*, and the Desert Tortoise Council Symposium. The last release, resulting in coverage on Channel 11 of the Halfway House, also resulted in 57 calls in one day for applications for tortoise permits.

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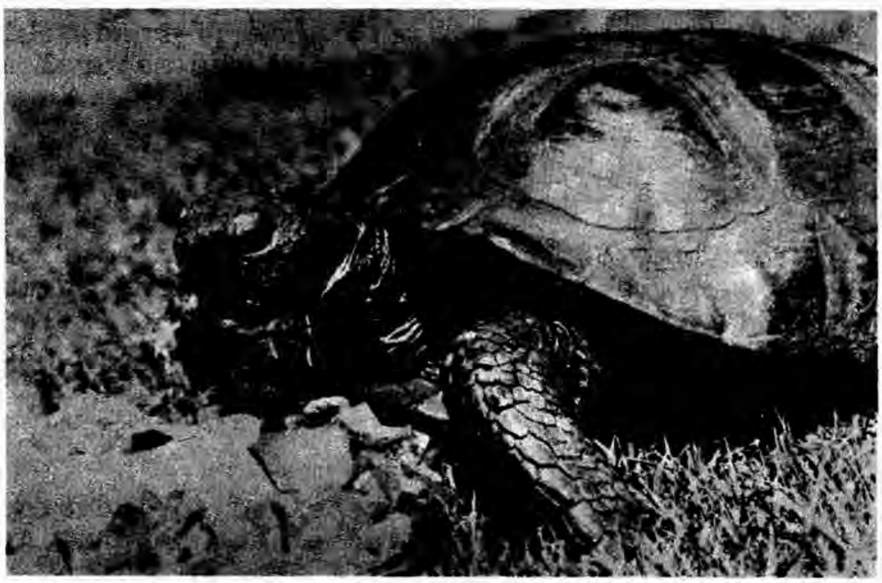

Maximus - 23 pounds, 15 inches carapace length
Photo by J. A. St. Amant

State Report - California

Bill Radtkey
Bureau of Land Management

The Bureau of Land Management is still working on a proposal for the Desert Tortoise Natural Area. There are 26,000 acres involved and approximately 9,000 are under private ownership.

The proposed Desert Tortoise Natural Area has been closed to off-road vehicles since 1973.

Problems presently being worked on include:

1. A Habitat Management Plan must be formulated.

2. The Natural Area is located near California City; agricultural development is encroaching on prime tortoise habitat; and off-road vehicle impact to the area surrounding the natural area is increasing.

3. Private land must be acquired; there are about 400 parcels of land.

4. An exchange of land with (BLM exchange of private parcels for natural resource land parcels) private landowners would cost $10-15 million. Two alternatives are being explored: 1) purchase of land by private individuals and 2) land acquisition by special congressional action.

In January, 1976, money was received for development of a management plan and protection of the Natural Area and for a full-time biologist. Jeff Aardahl is the biologist, and he will develop a Habitat Management Plan, visitor use plans, etc.

Additional monies are expected in 1977 for development of interpretive visitor program and facilities.

A Habitat Management Plan will be developed so that protection of the area can be enforced under the Sikes Act and the California Department of Fish and Game.

All grazing will be prohibited after April 1, 1976. However, the Bureau of Land Management cannot control grazing on private lands.

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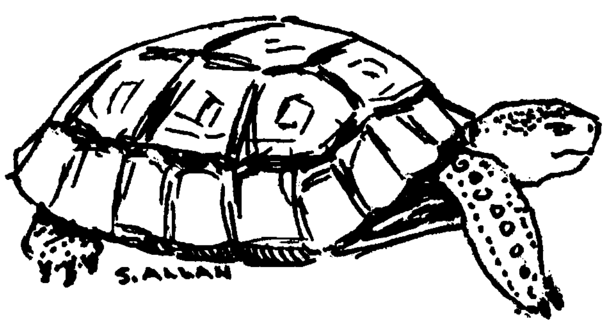
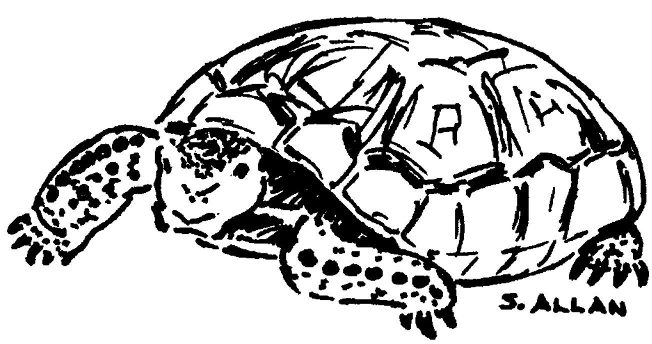
2800 Cottage Way
Sacramento, California 95825





State Report - Nevada

Paul Lucas
Department of Fish and Game

Nongame fish and game programs were not funded until 1973.

At the present time there are two nongame biologists on the Fish and Game staff - one is responsible for the eastern portion of the state and one for the western portion of the state.

The emphasis of the nongame program has been on raptor studies.

Under Nevada laws and regulations there is adequate provision for protection of the tortoise in the wild. It is illegal to hunt, trap, possess or transport tortoises in Nevada. Under a new law, General Regulation No. 1, the State can classify a native species with an endangered status. Under this regulation, the tortoise in Nevada is classified as rare and protected. The only other reptile protected in Nevada by this regulation is the gila monster, *Heloderma suspectum.*

There has been no inventory of tortoises in Nevada; however, it is estimated that there are approximately 7,000 captive tortoises in Nie and Clark Counties.

Lack of money has been a major limiting factor in expansion of nongame biological fish and game studies. There is before the Nevada Legislature at the present time a proposal for expansion beyond the existing nongame program. The program funding doubled from 1975 to 1976. It is expected to increase fivefold for 1977.

Listed below is the existing legislation on the desert tortoise in Nevada.

NRS 503.030. Possession of wildlife after end of open season. It is unlawful for any person to have in his control any wildlife or any part thereof, the killing of which is at any time prohibited, and the possession of such wildlife shall be prima facie evidence that it was the property of the state at the time it was caught,.....

NRS 503.597. Introduction into, removal from state of wildlife. It is unlawful, except by written consent and approval of the department, for any person to receive...or remove...from one portion of the state to any other, or to any other state, any aquatic life, wildlife, spawn, eggs or young of any of them.

NRS 503.600. Hunting, trapping desert tortoise, terrestrial turtle unlawful.

NRS 503.585. Gives the Fish and Game Commission authority to classify a species endangered which shall not be captured, removed or destroyed except by special permit.

NRS 503.584. States the people of Nevada have an obligation to conserve and protect various species of native fish and wildlife that are threatened with extinction.

Commission General Regulation 1. Classifies the desert tortoise, *Gopherus agassizi*, as a rare reptile under protected reptiles. Rare under this regulation defined as one that, although not presently threatened with extinction, is in such small numbers throughout its range that it may be endangered if its environment worsens.

NRS 501.065. Open season defined states there shall be no open season on those species of wildlife classified as protected.

Current Nevada law gives the desert tortoise sufficient legal protection from capture and harassment. Maximum protection of sustained wild populations is the Department's chief goal.

A large population of tortoises is believed to currently exist in the Las Vegas area. No exact figure is available but Ron Lee, Regional Game Assistant, estimates that at least two percent of the people in Clark County may have tortoises as pets which would total about 7,000. Betty Burge, University of Nevada, Las Vegas graduate student, has records on over 200 turned in during the last year.

A question arises about what we are to do with captive tortoises. A study of a reintroduction program in California found a survival rate of less than ten percent. Other complications worthy of study include mixing genetic strains, overloading land carrying capacity and disturbance of wild social structure - all factors discussed by this group in the past. The question remains unanswered now.

I am not aware of any intensive analysis on conflicts in Nevada. Possible factors as reported by Charles Marshall from California in his letter of April 14, 1974 include:

1. Rapid encroachment of habitat by man and his land use activities.

2. Automobile mortalities - on-and-off-road use.

3. Individuals taken for pets (illegal).

4. Shooting (illegal).

5. Commercial sale (illegal).

Illegal factors are thought to have been minimized through the Department's I & E and enforcement programs. All possibilities should be identified and evaluated during needed research and inventory programs.

There is a need for a basic inventory of distribution and population numbers along with periodic assessment of population trend. Also more research on population characteristics, habitat requirements, limiting factors and effect of various protection - management practices.

The Department's nongame program now has two people, but an intensive inventory is beyond our present capabilities. We do collect data through a wildlife sight record system gathered during other field work which should be helpful in future studies.

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State Report - Utah

Dale Arhart
Bureau of Land Management

There are approximately fifty square miles of tortoise habitat in Utah.

Past proposals to prohibit grazing in the tortoise habitat have not been implemented.

Tortoise studies by the Bureau of Land Management in the Beaver Dam Mountains have been implemented due to requirements of the Bureau of Land Management to assess grazing impacts - the results of the Natural Resource Defense Council lawsuit against the Bureau of Land Management.

Under the impact studies, Utah Bureau of Land Management has twenty impact study areas. One of these includes the Hot Desert Area - this is within Washington County and includes the Beaver Dam slopes.

Specific recommendations regarding grazing are being developed.

One area of the grazing impact studies will be to identify cattle and tortoise food requirements and competition.

Bureau of Land Management
P.O. Box 729
Cedar City, Utah

The Distribution of the Desert Tortoise

Robert Patterson

A study of the distribution of the desert tortoise, *Gopherus agassizi*, was undertaken in California. Museum records, literature records and personal sightings were used. Personal sightings involved professional herpetologists, informed amateurs, high school teachers, students and other laymen. Based on the present results, amateur data adds depth to a distribution study that is not normally available.

Traditional methods of determining animal distributions involve a literature search for published localities followed by a request of museums for their locality records. Visits are then made to these historical areas and an on-site search is then done in nearby areas. This is both costly and time-consuming, especially if the question is simply where has the animal been in historic times.

METHODS

The technique used in the present study involved collecting locality data from both literature and museum sources. This was followed by journal requests for locality records (Brattstrom and Patterson, 1972) and by personal letters to tortoise researchers asking for their locality records. The data collected was plotted on maps and nearby high schools and colleges were located, as well as, national monuments, national and state parks and nature museums. Letters were sent to each high school biology teacher, junior college teacher and park or monument ranger near one of the locality sites. They were informed of the study, its goals, and of all the sites in their vicinity. They were provided with a simple pictorial key to determine tortoise species (Brame and Pierson, 1969). Each letter included a self-addressed return postcard with a series of questions about tortoise population conditions, presence or absence of tortoises in the area, and a request for any new locality data. Because most of the people had had training in biology, their data was recorded as coming from a semi-professional source.

Letters and postcards were then sent to Chambers of Commerce in all areas historically containing locality sites for tortoises. They were asked to respond to questions about the tortoise population and its condition in their area. They were also asked to provide any new locality data they could. Letters and journal requests were also sent to known amateur herpetologists and their clubs asking for help (Patterson and Brattstrom, 1972).

SURVEY RESULTS

As shown in Figure 1, when semi-professional and amateur data is added to the distribution map, new areas and a more thorough coverage are obtained. Luckenbach (1975) has carried out extensive field studies and on-site visitations to determine the status of the desert tortoise in California and was able to determine actual population conditions. The data collected in the present study can also be used to determine changes in the population. The hypothesis of no change can be tested using a chi-square test and involving present and past tortoise sites.

The time span for information return is also important if a quick survey is called for. Amateur response time is 17 days on the average while personal and journal requests of professional herpetologists take about 2.2 months on the average. Museum and herpetological collections took 5.0 months on the average to respond. This means that a quick survey can be run using amateur data, especially if other groups are involved, such as, sportsmen, 4-wheel drive clubs, ORV groups and scout troops who enjoy short term but specific goal type projects.

LOCALITY DATA

Museum collections containing *Gopherus agassizi* are represented by the following abbreviations: American Museum of Natural History, AMNH; California Academy of Sciences, CAS; Stanford University Collection housed at the California Academy of Sciences, CAS-SU; Los Angeles County Museum of Natural History, LACM; National Museum of Natural History, USNM; San Diego Natural History Museum-Klauber Herpetological Collection, SDNHM; University of California, Museum of Vertebrate Zoology, MVZ; University of Kansas, Museum of Natural History, UK. All semi-professional and amateur data is noted with an * in the accompanying data.

Localities of *Gopherus agassizi* in California include: Imperial County: Chocolate Mountains W of Piccacho, E Chocolate Mountains about 20 miles E Beals Well (CAS-SU 9699), Colorado River 20 miles S Palo Verde (MVZ 58188), Fort Yuma (USNM 10398, 10412; CAS 13164; True, 1881), Midway Well, Milpitas Wash, Ogilby at junction of W Winterhaven, Santa Rosa Mountains*; Inyo County: Carnivore Ridge, Death Valley, Dale (Miller, 1932), 2 miles SE Emigrant unction, 11.5 miles SE Lone Pine near Olancha, Scotty's Canyon, Black Mountains 5 miles up canyon (Turner and Wauer, 1963), Wild Rose Canyon; Kern County: California City, 9 miles S California City (McGinnis and Voight, 1971), 1.7 miles N Highway 58 and California City, Castle Butte, China Lake, Desert Butte, Jawbone Canyon Road in wash 5 miles NW road, 0.5 miles E Mojave (Camp, 1917; MVZ 3609), Owen Valley Road 10 miles N Mojave (Miller, 1932, 1955), 4 miles N Red Rock Canyon (Nichols, 1957), Randsburg, Red Mountain, NW Flank, 4100 feet; Los Angeles County: Lovejoy Buttes (Miller, 1932, 1955), Lovejoy Springs (Bogert, 1937, SDNHM 6063), Mojave Desert (USNM 9251), 3 miles S Palmdale (Camp, 1916; Grinnell and Camp, 1917): Riverside County: Alice Mine at N end Riverside Mountains, Chuckwalla Valley near Desert Center*, Chuckwalla Mountains (Jaeger, 1955), Clemmens Well (MVZ 27467), Cottonwood Springs (Miller, 1932, 1955; MVZ 43038), Desert Center (SDNHM 35806, 35807), Hayfield, 1.5 mile S and 2 miles E Joshua Tree National Monument, Mais Canyon, Mecca (Camp, 1916; CAS 33332), E and N of Mecca (Miller, 1932), 12 miles NE Mecca in Cottonwood Mountains (Camp, 1916), Mecca Hills*, Orocopia Mountains*, NE base of Orocopia Mountains, 0.5 mile S Palm Springs, 1.25 mile W and 2.75 miles S Pinto Basin (MVZ 43040-43049), Pinto Basin, Mission Sweet Mine, 1 mile W and 3 miles S Pinto Mountains (MVZ 5555512), Salt Creek Wash, 4 miles SW Summit Railway Station; San Bernardino County: 12 miles N Amboy (Miller, 1932), Apple Valley*, Arrowhead junction (Klauber, 1932), 3 miles ESE Red Mountain at Atoloa (CAS-SU 21370), Bagdad (USNM 135987), Barstow (CAS 38717; UK 91353; AMNH 73811, 73813; SDNHM 17056, 24367; Camp, 1916; rant, 1946), 2 miles NE Barstow (MVZ 5554), Barstow Syncline, 7.5 miles S Barstow in Stoddard Valley, 3.8 miles NW Barstow in W Waterman Hills, 9 miles NE Barstow, Calico Mountains*, Cedar Canyon Road in Providence Mountains, 1.1 mile SE Cedar Canyon and Kelso-Cima oad, 7 miles N Cima in Ivanpah Mountains (MVZ 25360; Johnson, 1948), 7.2 miles NE and 9 miles NE

Cima-Ivanpah Road, Chemehuevi Mountains, Chemehuevi Wash, N side Clark Mountains (Johnson, 1948), Colton Well (Johnson, 1948), Dagget (USNM 18645; Meek, 1905), Danby Station 4 miles NW flank of Clipper Mountains, 1 mile W Earp, El Mirage Dry Lake on SW side, 3.2 miles NNW Essex, 9 miles NNW Essex, 12 miles NNW Essex, 7 miles NNE Essex at Black Canyon Road, Fort Mojave and about 12 miles from Fort (USNM), Fry Mountain Peak 5 miles W on power line road, Granite Pass, Kelbaker Road, Goffs (Camp, 1916), Hector (Klauber, 1932), Helendale (SDNHM 2539), 1 mile N and 3 miles N Hinkley, Hodge (USNM 71779; Grant, 1932, 1946), Indian Cove in Joshua Tree National Monument (Miller and Stebbins, 1964), 30 miles N Iron Mountain Pumping Plant*, SW Ivanpah (Johnson, 1948), Joshua Tree, 12 miles NE Joshua Tree, Joshua Tree National Monument (CAS-SU 131454), 3 miles E and 8 miles SE Joshua Tree, Kelso, 2.5 miles SW Kelso (Johnson, 1948), Kelso Dunes, Kramer (Camp, 1916; Lee, 1963; MVZ 3550), 2.4 miles N and 12 miles NE Boron near Kramer and Adelate Junction (SDNHM 40341-40342), Leach Point Valley as far N as Summit Crater (Grinnel and Camp, 1917; Stejneger, 1893; USNM 19254), 8 miles N Lucerne Valley, Ludlow (Klauber, 1932, SDNHM 7618), 8 miles S. Ludlow, Midway (Klauber, 1932), Mojave River N past Ore Grande*, 12 miles NW Needles, 12 miles W Needles (Miller, 1932; MVZ 24846, 66905), Old Woman Mountains, Pisgah Crater, 1 mile E Pisgah Crater, Providence Mountains (Johnson, 1948), Salt Water Canyon, San Bernardino City (CAS-SU 3758), San Bernardino County (USNM 19254; Stejneger, 1893), 10 miles S and 17 miles S Searchlight (Klauber, 1932), Sheephole Pass to Yucca Valley*, Solado Valley (True, 1881; USNM 7888), Texas Rock Quarry, 5 miles NE Lucerne Valley in Turtle Mountains*, 10 miles W and 3 miles S Twenty-Nine Palms (MVZ 41152; Miller and Stebbins, 1964), Victorville (Camp, 1916), Vidal, 8 miles N and 1.6 miles N Vidal, Warrens Well, 3 miles S Warrens Well (Miller and Stebbins, 1964), Whipple Mountains*, Wild (Klauber, 1932), Wildhorse Canyon Road 1 mile W. Mudhill Campground, Wildhorse Wash about 3 miles W road, 40 miles N Yermo (SDNHM 11559; San Diego County: Santa Rosa Mountains in S end.

CONCLUSION

In summary, then, a quick survey could be run using the following steps: A survey of the literature, requests of museums for locality records, contacting biology teachers at high schools and colleges near known localities, requests for locality data in professional journals, personal letters to professional herpetologists involved in work in the area or with the animal, and involvement of amateurs using simple key and specific questions they reply to with a self-addressed postcard.

ACKNOWLEDGEMENTS

I would like to thank Dr. B. H. Brattstrom for his very kind help with this study.

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696 Milford Road
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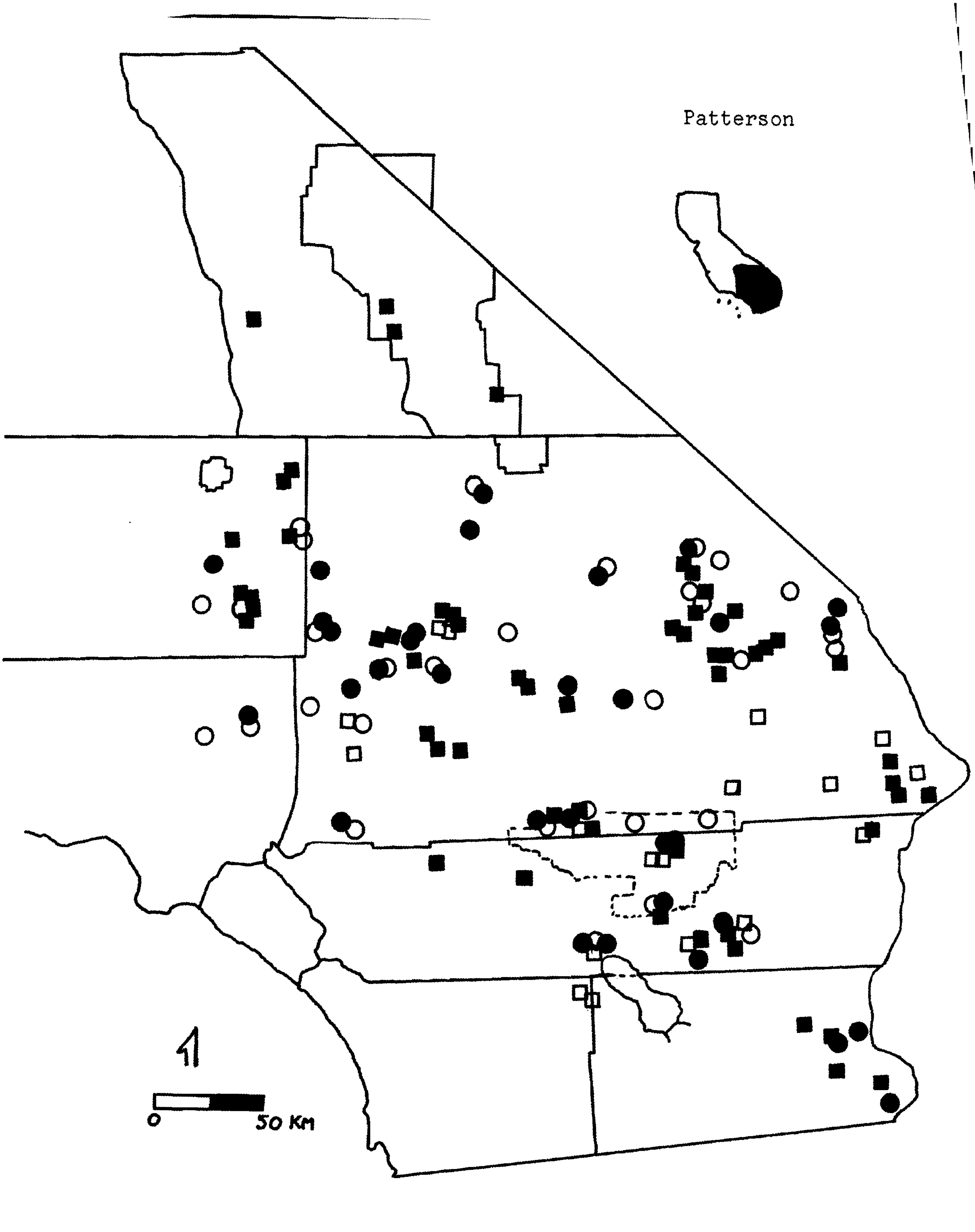
Figure 1. Localities for *Gopherus agassizi* in California. Small map shows area of California covered in larger map. Solid circles are museum specimens, open circles literature records, solid squares field records of professional herpetologists and open squares are amateur observations and semi-professionals.


Patterson
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Field Estimates of California Populations of *Gopherus agassizi*: I. Procedures

Roger A. Luckenbach

A study was undertaken on the distribution and demographic status of the desert tortoise, *Gopherus agassizi*, in California. Since the entire state was surveyed, a sampling procedure was employed to determine relative abundance. The procedure was to drive or walk to a spot randomly chosen, then walk in a compass bearing for one mile, turn right or left and walk another mile and so on until a one mile square quadrat had been walked. During the quadrat surveys, search was made for tortoises, burrows, scats and other signs and records were made of vegetation, soil type and elevation. Data were compared to areas of known density to yield an index of relative density. This index was then joined with broader habitat surveys to develop a map of relative abundance of the tortoise within California. A distributional map was similarly developed and an attempt was made to develop a matrix delineating the range of environmental factors that affect tortoise distribution and abundance in California. The survey procedure is outlined and a data sheet is presented to facilitate future surveys.

Attempts to know the numbers of animals living on a given area can never be absolute. At best, if the area is relatively small, reasonable estimates can be made. If the area is large, the estimates, regardless of methods used, will be unreasonable. Aerial censuses of large ungulates and waterfowl are perhaps exceptions. Despite the inherent difficulties of such data, they are not without their uses. The present study is no exception. While it deals with the relative densities of an animal that is difficult to locate and seasonally active and covers an area of approximately fourteen million acres, it still offers some pragmatic information, a relative scale of densities to compare against, and a point of departure for other studies.

PURPOSES

The purposes of this study were to: 1) determine the current distribution of the desert tortoise in California, 2) assess its overall demographic status and in particular locate areas of high density, and 3) broadly identify its habitat requirements.

This discussion will stress the field methods employed in this study in hopes of standardizing future survey efforts. A complete discussion of the survey can be found in Luckenbach (1975).

DETERMINATION OF DISTRIBUTION

Patterson (this volume) has conducted a thorough survey of literature, museum, and field note localities to determine the historical distribution of the desert tortoise in the southwest. By using only animals that were encountered during the course of this survey or other contemporary field localities, a current picture of tortoise distribution was developed. A comparison of both findings is most elucidating in that Patterson's represents a time study, whereas the present one is a space study. Noteworthy changes in distribution are made evident. For instance, animals from the southeastern corner of the state have become exceedingly rare if not extirpated in such areas as the Chocolate Mountains and Meca Hills of Imperial County. Map 1 denotes then what represents the present distribution of desert tortoise in California. The darkened line represents what I feel to be the natural limits of their range and is based largely on locality records and elevational and vegetational information. Localities outside this line such as those at Little Lake, Inyo County and the Santa Rosa Mountains in Anza Borrego State Park, represent liberated animals.

ESTIMATION OF POPULATION DENSITY

Population density is a measure of abundance and is expressed in individuals per unit area. There are many ways to measure density. Southwood (1966), Lamotte and Bourliere (1969) and Mosby (1963) provide reviews of some of these procedures. The ideal is to measure <u>absolute density</u>, the total number of individuals within a definable area or community. Methods for determining absolute density are (a) total population count,

(b) harvesting, and (c) estimates from survey techniques such as mark-recapture indices or quadrat sampling. The exact method depends on the nature of the animal species under investigation and the length of time that can be devoted to the study. Bird populations are best studied by sampling singing males (Kendeigh, 1944) but mark and recapture may be employed for long-term studies (Lack, 1966). Mammals are traditionally censused by Lincoln index (Lincoln, 1930) or Jolly Model (Jolly, 1965), although Zippen (1956) has presented an interesting alternate procedure. Busack and Bury (1974) have recently applied this to censusing of lizard populations. Ordinarily, tortoise densities would be calculated from total counts or mark-recapture methods. Burge and Bradley (this volume) and Marlow (1974) provide examples of populations studies to which mark-recapture methods have been applied.

When it is impractical to determine the absolute density of a population or the problem in question does not require that level of information or if the length of time or size of census area limits data gathering, measures of relative density can be used. Relative density depends upon the collection or measures of samples that represent a relatively constant but unknown relationship to the population size. Thus the estimate of density is not a reliable measure of absolute density but rather an index for comparing two populations. This is the first study to make extensive employ of quadrat sampling methods for estimation of relative densities of such a large population of animals over such a large geographic area.

Population estimates for the Desert Tortoise Reserve, Kern County, are given by Marlow (1974) and are known for an area north of Hinkley, San Bernardino County (Luckenbach, 1973, 1974). A series of quadrat samples conducted on these two plots yielded a baseline of known absolute density with which to compare successive quadrat surveys (see Luckenbach, 1975).

Since field work was conducted during the late summer and into the fall and winter of 1974-1975, peak aboveground activity was not encountered. Therefore, signs of tortoise presence rather than absolute tortoise numbers became important measures of tortoise abundance.

Signs used were: 1) tortoise burrows, 2) scats, 3) shells, and 4) tracks. These measures of relative density were similarly standardized by comparing the frequency of these indicators from an area of known density to an area of unknown density. Tortoise presence criteria are here elaborated to better understand the censusing method.

Burrow Counts. The relationship between burrow numbers and tortoise numbers varies greatly with geographic location. Woodbury and Hardy (1948) report a ratio of 4:1 for summer burrows to winter dens. In California, burrow distinction is not nearly as evident and consequently, no such ratio exists. Thus one tortoise may use one burrow continuously for several weeks, then move and begin using another more frequently. Alternatively, it may simply make use of several burrows within its home range. Also, California tortoises may spend the winter dormancy period in only a very shallow burrow so there is no or little seasonal distinction. A good index then for California is to assume a ratio of one tortoise to each burrow.

In making burrow counts, it is also important to note both the size and shape of the burrow and the activity indicators, such as plastron-slide marks, the amount of debris at the mouth of the burrow, lack of spider webs or crescent-shape of existent webbing, and tracks to determine if it is an active burrow and the size of animal using it. During winter and fall these signs are notably lacking and it is impossible to determine whether it is an occupied or unoccupied burrow unless the animal is in sight. Skill in locating burrows is crucial in the censusing process. Tortoise burrows are distinctly crescent-shaped and slant downwards at a slight angle. If the entrance is crescent-shaped but suddenly tapers to a rounded hole, it is likely a kangaroo rat, *Dipodomys sp.*, hole. Ground squirrels, *Citellus sp.*, construct very rounded burrows. Size of burrows is directly related to the size of the animal using it, although small ones may temporarily use larger unoccupied burrows. Burrows constructed by juveniles and small tortoises are themselves small and may resemble rodent or lizard burrows further complicating the procedure.

Scats. Scat presence merely confirms that a tortoise was once there. Size of the scat can loosely be correlated with tortoise size. Tortoise scats are distinctive and not to be confused with fecal matter left by any other desert vertebrate (see Figure 1). They are cylindrical, often tapered to a point at one end, composed largely of vegetative matter but may have large amounts of sand and grit mixed in or consisting entirely of sand. (The first three of the right column of Figure 1 are examples.) Recent scats have a shiny blackish coating. With exposure, this is worn off and the scat disintegrates rapidly (the last two of the right column of Figure 1). Scats left in early spring disintegrate readily being composed of flowering stalks and other succulent portions of annuals. In California, the summer food consists of the dry portions of annuals, frequently grasses and these scats persist for longer intervals. Predator scats should also be examined to determine predation pressures on tortoises.

Tortoise Shells. Likewise, the presence of tortoise shells indicates that tortoises live or formerly lived in an area. Shells, however, may be transported by carnivores and by humans, so mere presence of a shell in a particular locality does not necessarily mean that the tortoise succumbed at that site. The aging sequence of the shell is indicative of the relative time since the animal's death. The sequence from the time the scutes adhere tightly to the bony skeleton takes from six months to a year; after one to two years, the scutes gradually dry and lighten in color and then peel, leading to the falling apart of the underlying bony structure, which may take from two to five years. A relative aging sequence is used on the data sheet (see Appendix). The entire sequence is described by Berry (1974).

Tortoise Tracks. The use of tortoise tracks in assessing the estimation of population size is severely restricted. First, it may only be used in areas of aeolian sand and, secondly, only during periods of above ground activity. When both requirements are met, the data return can be quite high. Careful tracking of individual tortoises may yield data on home range size, burrow usage, reproductive state, and feeding habits. Courting animals may often leave a small depression behind from mating; signs of recent urination may also be indicated. If the tracks lead to a certain plant species and show signs of delaying or moving about it, it may then be closely examined to determine whether or not it has been eaten. Figure 2 shows tracks made in aeolian sand near Hinkley, San Bernardino County. Note the main track is left by the hind foot pad, the forelimbs leaving only a small depression. Note also the tail drag indicative of males.

DETERMINATION OF HABITAT REQUIREMENTS

During the surveys, records were made of vegetation, soil type and elevation. Tortoise presence was then correlated with environmental parameters to provide for a first attempt at an environmental matrix for the desert tortoise. (Figure 3.) Precipitation was estimated from the nature of the plant community (after Munz, 1959) present, and elevation. Annual bloom potential is totally subjective, although part of the criteria was based on the amount of remnant annual growth plus elevation and soil type. Perennial diversity was indicated by comparison of the number of different perennial species present in a survey area.

Results of the quadrat surveys were combined with habitat maps and extrapolated to yield a relative densities map for the desert tortoise in California and is illustrated elsewhere (Luckenbach, 1975).

PROCEDURES AND DATA SHEET

The procedure during the survey was to drive or walk to a spot randomly chosen, then walk in a compass bearing for one mile, turn right or left and walk another mile and so on until a one mile square quadrat had been walked. Average time for the survey was 4.6 hours. One half mile quadrats averaged 2.3 hours for completion. Any part of a mile quadrat may be walked and calculations per square mile made accordingly. The survey need not be a quadrat but could be a simple half mile rectangle to yield a transect. If the area walked is known then figures can be made on a per square mile basis.

The data sheet appendixed was developed by Dr. Kristin Berry of the Bureau of Land Management and is included with her kind permission. It is largely self-explanitory with one side being directions and illustration of measurements and indexes. (All measurements should be made in metric readings.) It is included so that a standardized form might be used for future surveys and data may be gathered on other areas of the tortoise's range in the southwest. The data sheet can be duplicated and completed forms can be mailed to the Desert Tortoise Council.

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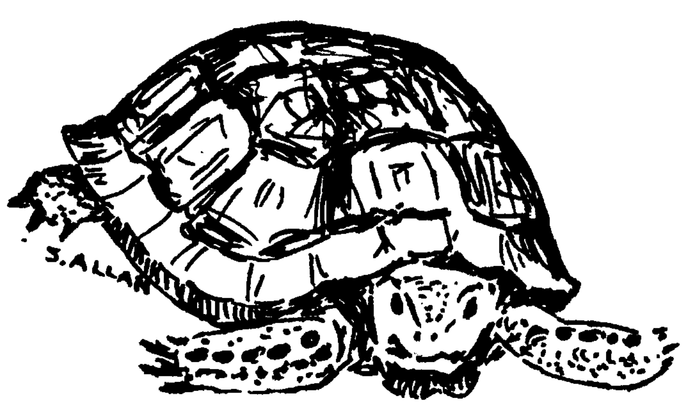
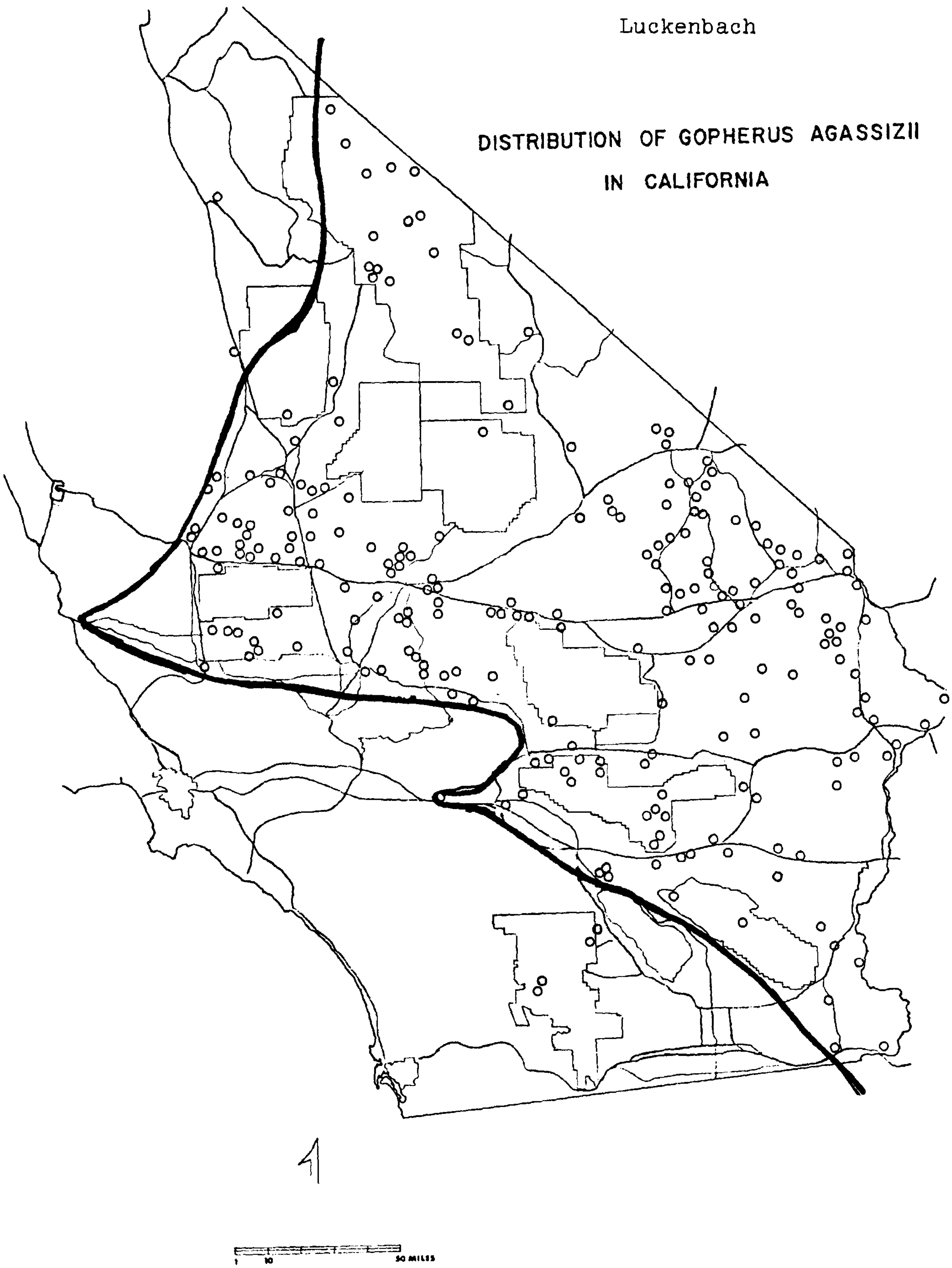


Luckenbach


DISTRIBUTION OF GOPHERUS AGASSIZII
IN CALIFORNIA
50 MILES

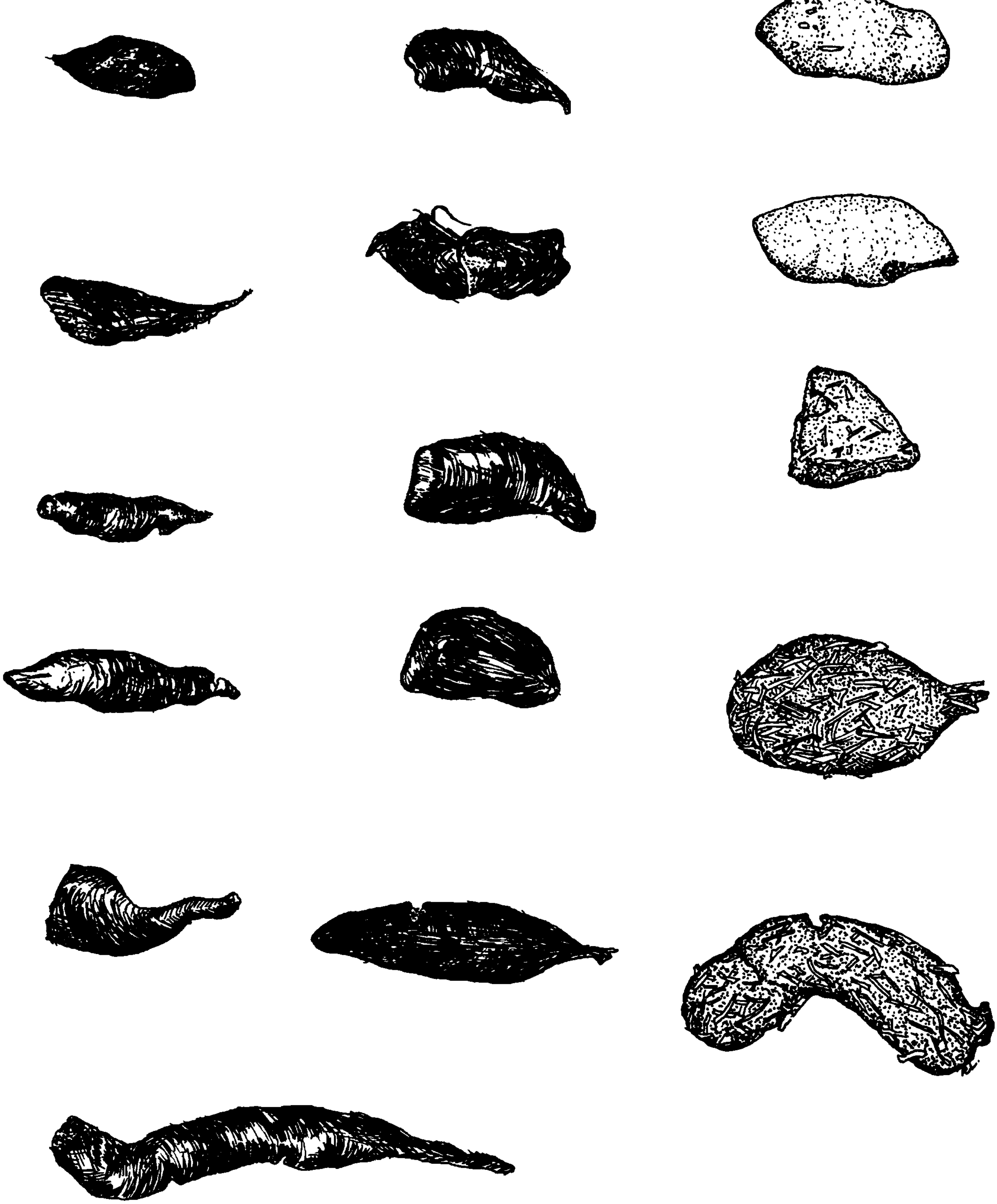


Figure 1. Examples of desert tortoise scats. (From a series collected near Hinckley, San Bernardino, California.)

Figure 2. Desert tortoise tracks made in aeolian sand.

ENVIRONMENTAL MATRIX FOR THE DESERT TORTOISE IN THE PROVIDENCE MOUNTAINS REGION

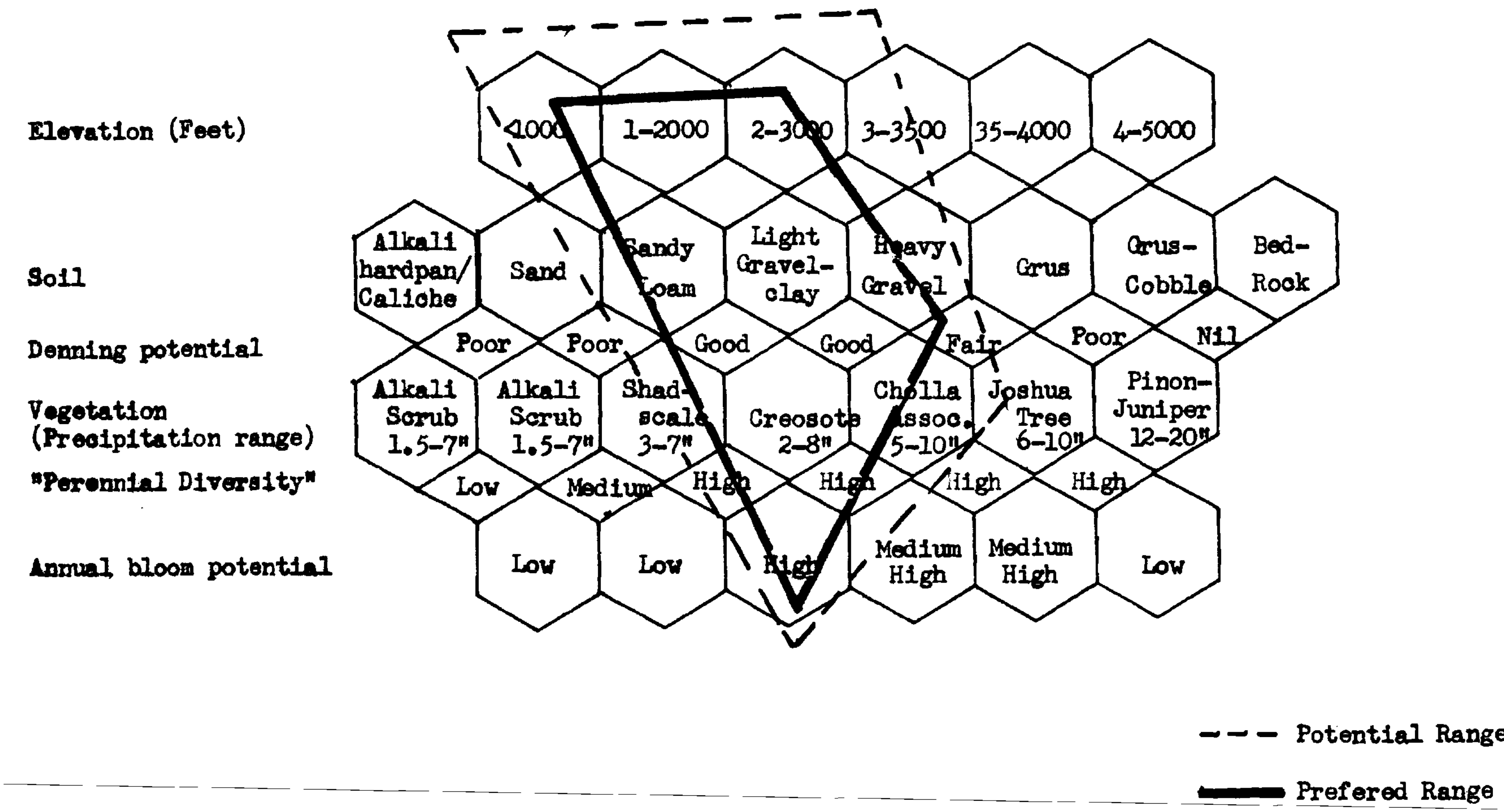


Figure 3. Environmental matrix for the desert tortoise in California.

TEST FORM

CALIFORNIA DESERT PROJECT
STANDARD UNIT RECORD
FOR
DESERT TORTOISE SURVEY

[1] RECORD TYPE	W 2
[2] STATE	
[3] DISTRICT	
[4] PLANNING UNIT	
[5] SITE NUMBER	
[6] COUNTY	
[7] ACTION [A = ADD C = CHANGE D = DELETE]	

[8] SECTION I — GENERAL SITE DESCRIPTION

[9] DATE OF SURVEY YR./MO./DAY	[10] HOUR	[11] RECORDER	[12] WINDSPEED	WEATHER CONDITIONS [13] TEMP	WEATHER CONDITIONS [14] CLOUD CO'V	[15] ASPECT	[16] SLOPE % AVG.

[17] GEOMORPHOLOGY	[18] ELEVATION	[19] TEXTURE TYPE	[20] VEGETAL ASPECT	[21] HABITAT CONDITION	TRANSECT [22] LENGTH FEET	TRANSECT [23] WIDTH

[8] SECTION II — LOCATION DATA

[9] TOPOGRAPHIC QUAD SCALE	[9] TOPOGRAPHIC QUAD NAME	SITE NAME

CADASTRAL GRID LOCATION [10] TOWNSHIP	[11] RANGE	[12] SECTION	[13] SUBDIVISION	UTM GRID LOCATION [14] ZONE	[15] NORTHING	[16] EASTING

[8] SECTION III — BURROW AND SCAT DATA

[9] LINE #	BURROWS [10] LENGTH	[11] WIDTH	[12] HEIGHT	[13] SOIL COVER AT ENTRY	[14] CONDITION	[15] LOCATION	[16] SCATS	SCATS [17] SIZE	[18] CONDITION	[19] LOCATION
01										
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COMMENTS:

INSTRUCTIONS

SECTION I - General Site Description

9) Month - Date - Year

10) Note whether Pacific Standard Time or Pacific Daylight Time

11) Name of person undertaking survey and agency represented

12) Windspeed (technique for estimates used by Cal. Dept. Fish & Game)

Beaufort Nr.	Wind Speed (mph)	Indicators of Wind Speed
0	less than 1	Smoke rises vertically
1	1 to 3	Wind direction shown by smoke drift
2	4 to 7	Wind felt on face; leaves rustle
3	8 to 12	Leaves & small twigs in constant motion; wind extends light flag
4	13 to 18	Raises dust and loose paper; small branches are moved
5	19 to 24	Small trees in leaf begin to sway; crested wavelets form on inland waters.
6	greater than 24	

13) Air temperature about 3 feet above soil surface. If no thermometer is available; estimate and note if calculated in Fahrenheit or Centigrade.

14) Cloud Cover (used by FAA)

1 clear = less than 1/10 cloud cover

2 scattered = 1/10 to 5/10s cloud cover

3 broken = 6/10s to 9/10s cloud cover

4 overcast = more than 9/10s cloud cover

5 fog, drizzle

6 showers

17) Geomorphology. Use terms such as:

arroyo - vertical,- walled, flat-floored channel of ephemeral stream of the arid southwest

gully - any erosion so deep that it cannot be crossed by a wheeled vehicle or eliminated by plowing

canyon - a steep - walled chasm, gorge or ravine

sand dune
valley
hill
ridge

(Continued on reverse)

mesa

alluvial fan - a cone shaped deposit of alluvium made by stream or intermittent water flow where it runs out onto a level plain

bajada - the nearly flat surface of a continuous apron consisting of confluent alluvial fans

20) Vegetal Aspect. If possible, note the dominant plant shrubs by aspect (the tallest or most obvious) and the four or five most common species

21) Habitat Condition
1. undisturbed, virgin
2. disturbed
3. disturbed - cattle grazing
4. disturbed - sheep grazing
5. disturbed - burro grazing
6. disturbed - wild horses
7. disturbed - mining
8. disturbed - numerous roads, trails
9. disturbed - off-road vehicle use: motorcycles
10. disturbed - off-road vehicle use: 4-Wheel vehicle
11. disturbed - housing developments, interspersed pvt. land
12. disturbed - agriculture
13. disturbed - other

23) Transect width: the usual width covered by one person is about 10 yards

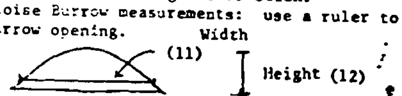
SECTION II

9) Site Name. Note if area has a place name, such as Lanfair Valley, Piute Valley, Providence Mtns., etc.

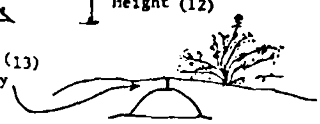
SECTION III - Burrows

10) Burrow length. Estimate approximate length by using a bamboo pole, fishing rod or stick.

11-13) Tortoise Burrow measurements: use a ruler to measure burrow opening.



Soil cover at entry



14) Condition
1. active, tortoise inside or present recently
2. in good condition, but apparently not used recently
3. good, but entrance filled or partially filled with cobwebs and/or debris
4. taken over by small mammals
5. entrance excavated by predator or large mammal
6. tunnel excavated or caved in

15) Location of Burrow - examples

1. between shrubs, in open
2. opening at base of shrub
3. opening inside shrub
4. opening on bank of wash
5. opening in boulders

16) Scats:
1. present at burrow entrance or inside
2. not present

Scats

17) Size. Measure length in mm or inches

18) Condition. Refers to age
1. fresh, wet or freshly dried
2. dried, age undetermined
3. white

19) Location
1. in burrows
2. in open
3. under shrubs

SECTION IV

10) Live or Shell

12) Size - Measure with calipers from anterior nuchal scale to posterior marginal/

(8) SECTION IV	LIVE TORTOISE, SHELLS, SHELL PARTS DATA						
5 LINE #	(10) LIVE REPORT (L or S)	(11) SEX	(12) SIZE	(13) LOCATION	(14) ACTIVITY	(15) CONDITION	(16) AGING
01							
02							
03							
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12							

(8) SECTION V	TRACKS DATA				
5 LINE #	(10) WIDTH	(11) SEX	(12) LOCATION	(13) AGE	COURTSHIP RINGS
					(14) LENGTH / (15) WIDTH
01					
02					
03					
04					
05					
06					
07					
08					

REMARKS:

13) Location.
1. in open
2. in shrub
3. in burrow
4. other

14) Activity.
1. basking in sun in open
2. basking in sun at burrow entrance
3. feeding
4. travelling
5. interacting with another tortoise
6. entering burrow
7. emerging from burrow
8. inside burrow

15) Condition.

Health of Live Tortoise
1. undisturbed, no marks, appears healthy
2. shell chewed by predator
3. shell cracked or broken
4. missing limbs
5. ticks
6. runny nose
7. peeling scutes and/or scales
8. other

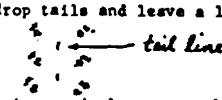
State of Shell
9. entire
10. chewed by predator
11. cracked or broken, crushed
12. bullet holes
13. limb or head present only
14. tortoise parts in predator scat

16) Aging of Shell. Refers to length of time since Tortoise expired.
1. shell is color of normal tortoise shell & scutes tightly adhere to bone
2. scutes peel easily from bone
3. scutes have peeled off of bone
4. bones are falling apart, scutes are pale & growth rings are peeling
5. bones present only, scattered

SECTION V.
TRACKS

10) Width. Under certain circumstances, tortoises leave foot prints in soft soils. Note width between inside of tracks:

11) Sex. Males frequently drop tails and leave a line
1. male
2. unknown



12) Location. Include footprints and plastron marks
1. in burrow
2. burrow entrance or mound
3. in open

13) Age of Tracks. Tracks fade and disappear with time. Wind and rain can obliterate them.
1. fresh, nail and scale marks clear and obvious
2. nail marks only
3. slight depressions of paired footprints

Courtship Rings

14) Tortoises leave round, oval, elliptical or odd-shaped depressions
15) when they court, mount, and copulate. Measure length and width of depressions.

TEST FORM

CALIFORNIA DESERT PROJECT STANDARD UNIT RECORD FOR DESERT TORTOISE SURVEY

[1] RECORD TYPE	W	2
[2] STATE		
[3] DISTRICT		
[4] PLANNING UNIT		
[5] SITE NUMBER		
[6] COUNTY		
[7] ACTION [A=ADD C=CHANGE D=DELETE]		

[8] SECTION I GENERAL SITE DESCRIPTION

[9] DATE OF SURVEY YR./MO./DAY	[10] HOUR	[11] RECORDER	[12] WINDSPEED	WEATHER CONDITIONS [13] TEMP.	WEATHER CONDITIONS [14] CLOUD COV.	[15] ASPECT	[16] SLOPE % AVG.

[17] GEOMORPHOLOGY	[18] ELEVATION	[19] TEXTURE TYPE	[20] VEGETAL ASPECT	[21] HABITAT CONDITION	TRANSECT [22] LENGTH (FEET)	TRANSECT [23] WIDTH

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[9] TOPOGRAPHIC QUAD SCALE	[9] TOPOGRAPHIC QUAD NAME	SITE NAME

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[8] SECTION III BURROW AND SCAT DATA

[9] LINE #	BURROWS [10] LENGTH	[11] WIDTH	[12] HEIGHT	[13] SOIL COVER AT ENTRY	[14] CONDITION	[15] LOCATION	[16] SCATS	SCATS [17] SIZE	[18] CONDITION	[19] LOCATION
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[8] SECTION IV				LIVE TORTOISE, SHELLS, SHELL PARTS DATA			
[9] LINE #	[10] TYPE REPORT [L-or-S]	[11] SEX	[12] SIZE	[13] LOCATION	[14] ACTIVITY	[15] CONDITION	[16] AGING
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[8] SECTION V			TRACKS DATA			
[9] LINE #	[10] WIDTH	[11] SEX	[12] LOCATION	[13] AGE	COURTSHIP RINGS	
					[14] LENGTH	[15] WIDTH
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REMARKS:

A Comparison of Size Classes and Sex Ratios in Four Populations of the Desert Tortoise

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The size or age classes and sex ratios of four populations of the desert tortoise, *Gopherus agassizi*, are compared and analyzed. Two populations are in California (Salt Wells Valley, Desert Tortoise Natural Area), one in Nevada, and one on the Beaverdam slopes of southwestern Utah. Three have similar values for size or age classes: 42-58% adults, 14-17% subadults, 18-33% juveniles, 5-10% very small tortoises, and 1-2% hatchlings. The ratios of adults to nonadults are close to 1 to 1 in these three study areas. The fourth, the Utah population, was substantially different with 90% adults and very low percentages of juveniles, very small tortoises, and hatchlings. The ratio of adults to nonadults was 9 to 1. Sex ratios were skewed in favor of females in two populations and in favor of males in two others; all were close to 1 to 1. The Utah population has shifted values for sex ratios during the last 40 years from 66 males to 100 females (or 133 males to 100 females) to 233 males to 100 females. The effects of collecting and habitat deterioration, particularly grazing, on size or age classes and sex ratios are discussed.

INTRODUCTION

In the last five years, there has been growing concern among federal and state agencies, academic and lay experts, and conservation organizations for wild populations of the desert tortoise. The desert tortoise is believed to be declining in the wild because of collections for pets and for sale and because of habitat deterioration and loss. At present, habitat deterioration and loss are considered the more serious problems. Sources of loss include surburban sprawl, agricultural development, mining, grazing of livestock and exotic animals, existence of and creation of new highways and roads, and off-road vehicle recreation.

Scientists, managers of public lands, and members of the Desert Tortoise Council are concerned about the population declines and habitat losses. Current research goals of the Desert Tortoise Council focus on how to document past events, on measuring impacts of deleterious activities, determining current status of populations, and analyzing population condition.

There is little historical data from field studies to document population conditions in the past. The study by Woodbury and Hardy (1948) in southwestern Utah stands alone as the only long term research project on a wild population. As if lack of field data were not enough, there are the added problems of working with a species that lives to be 60 to 100 years of age, requires 15 to 20 years to reach sexual maturity, and has a low reproductive potential. Traditional population studies could require decades.

The situation is not hopeless, however. There are certain methods of study that can reveal information on population status and condition. The density, age or size structure, sex ratios, and mortality rates of a population can provide indications of population health. For example, some trouble indicators might be: change in sex ratios, particularly decline in numbers of adult females; sudden, or locally high mortality in juveniles or adults; and a very low percentage of hatchlings and juveniles coupled with a high percentage of old individuals. If the population contains primarily old individuals and has few hatchlings or young animals, we might conclude that there are potential problems with reproduction or survivorship of the young and small age classes. In contrast, we might expect a healthy population to possess an age or size structure that has remained stable for many years, to contain approximately equal numbers of males and females (or a slightly higher percentage of females), and to produce young individuals regularly.

Data on habitat type, habitat condition, population density, size class composition, and sex ratios are presented for four desert tortoise populations. Two populations occur in California, one in Salt Wells Valley on the Naval Weapons Center, China Lake, and the other in the proposed Desert Tortoise Natural Area. The third site occurs in southern Nevada and the fourth in southwestern Utah. Interpretations are offered for the similarities and differences in size classes and sex ratios in the four populations and predictions are made on composition of healthy populations.

SIZE OR AGE STRUCTURE AND SEX RATIOS OF FOUR TORTOISE POPULATIONS

Salt Wells Valley, Naval Weapons Center, China Lake, San Bernardino County, California. This low density population occurs on the extreme northwestern edge of the geographic range. The habitat is variable with valleys of windblown sand, gently rolling hills with desert pavement and scattered rock, and ridges with outcrops of exfoliating granite; elevations range from 2100 to 1700 feet. There is a 5 percent cover of vegetation, which is primarily composed of creosote bush, *Larrea divaricata*, and burrobush, *Ambrosia dumosa*, with traces of Nevada joint fir, *Ephedra nevadensis*, cheesbush, *Hymenoclea salsola*, Fremont dalea, *Dalea fremontii*, Anderson thornbush, *Lycium andersoni*, desert alyssum, *Lepidium fremontii*, desert straw, *Stephanomeria pauciflora*, Indian rice grass, *Oryzopsis hymenoides*, and others (Berry, 1974b).

The habitat has had disturbances in the past. A single lane paved road was constructed through the study site in about 1945 and was probably used regularly between 1945 and 1950. However, traffic was limited to a few government employees. Between 1950 and 1971, only an occasional police vehicle penetrated the area. However, we can assume that tortoises were probably collected along the roadway and some could have been released; one employee released six captives about 1.5 miles away during the 1960s (Berry, 1974b).

During a two year study from 1971 to 1973, 48 tortoises were marked in an area of 5.3 square miles. Based on mark and recapture data, the 48 tortoises were believed to constitute almost the entire population in the area. Densities were estimated at nine tortoises per square mile.

The size or age structure of the population was assessed by dividing the population into five size or age classes. The classes are based on size (carapace length), shell hardness, appearance of sexual characters, and estimated size at first reproduction. The classes are defined as hatchlings (40-60 mm carapace length); very young or small tortoises (61-100 mm carapace length); juveniles (101-170 mm); subadults (171-214 mm); and adults (215 mm). The population was composed of 58 percent adults, 17 percent subadults, 19 percent juveniles, 5 percent very small tortoises and 2 percent hatchlings. The sex ratio of adults and subadults was 39 males to 100 females (Berry, 1974b).

The Desert Tortoise Natural Area, Eastern Kern County, California. This habitat, lying at elevations of 2900 to 3000 feet has a diverse creosote bush scrub community with elements of joshua tree woodland. There are over 160 species of plants in the area, 104 of which are annuals. Common shrubs include creosote bush, burrobush, Nevada joint fir, California buckwheat, *Eriogonum fasiculatum*, and goldenhead, *Acamptopappus sphaerocephalus*.

The tortoise populations in the Desert Tortoise Natural Area have received impacts from vandalism (shooting) and collections. As recently as five years ago, a pet collector from Bakersfield was arrested in the vicinity with over 150 tortoises in a truck. There also has been damage to the habitat from roads constructed for mining and access to private lands, from mining pits, from sheep grazing, and from off-road vehicle use (Berry, 1975ab).

Although impacts have been extensive and long term, the area still supports a good population of tortoises. One hundred three individuals were marked in an area of approximately one square mile. Based on mark and recapture data, the marked population is estimated to compose 50 percent of the actual population. Densities are estimated at 150 to 200 tortoises per square mile. The marked population was composed of 42 percent adults, 14 percent subadults, 33 percent juveniles, 10 percent very small tortoises and 2 percent hatchlings. The sex ratio of adults and subadults was 87 males to 100 females (Berry, 1975ab).

About five miles to the southwest in the same Natural Area, Ron Marlow, a graduate student at the University of California at Berkeley, has a study area with about 300 marked tortoises. He also has noted that about 42 percent of his marked animals are adult and has similar figures for sex ratios and hatchlings (Marlow, personal communication).

The Arden Study Area, Nye County, Nevada. During 1975, Burge (1976) marked over 100 desert tortoises in a study area in southern Nevada. The habitat has a vegetative cover of 3 percent, which is composed primarily of Mojave Yucca, *Yucca schidigera*, creosote bush, burrobush, California buckwheat, and Fremont dalea. The topography consists of desert pavement intersected by dry washes; the elevation is 2700 feet. The area has received little disturbance from human-related activities (Burge, 1976).

Densities of desert tortoises are estimated at 86 to 102 per square mile. Using the previously described categories for size or age classes, the population is composed of 55 percent adults, 17 percent subadults, 18 percent juveniles, 10 percent very small tortoises, and 1 percent hatchlings. The sex ratio of combined size classes of subadults and adults was 136 males to 100 females (Burge, 1976).

The Woodbury-Hardy Study Area on the Beaverdam Slopes, Washington County, Utah. From 1936 to 1946, Woodbury and Hardy maintained a study area in extreme southwestern Utah on the Beaverdam slopes (Woodbury and Hardy, 1948). The site, at elevations of 3200 to 3500 feet has a joshua tree woodland plant community. In 1941, the perennial vegetation was composed primarily of joshua trees, creosote bush, burrobush, winter fat, *Eurotia lanata*, Anderson thornbush, Nevada joint fir, galleta grass, *Hilaria rigida*, and bush muhly grass, *Muhlenbergia porteri*, (Hardy, 1945).

The Beaverdam slopes have a long history of disturbance from livestock. Nearby St. George was settled in 1862, and with the settlements came livestock grazing in the Beaverdam area. By the time Woodbury and Hardy began research, cattle and sheep had probably grazed there for 60 years. During the 1930's and 1940's sheep grazed the annual wildflowers in spring and cattle fed on perennial vegetation in winter (Woodbury and Hardy, 1948, page 171). Dr. Hardy (personal communication) reported that the tempo of livestock use increased during the 1940's that corrals and sheds for shearing sheep were set up within one-half mile to one mile from the study area, and that new watering tanks were built for cattle. Between 1936 and 1946, 281 tortoises were marked in an area of two square miles; densities were estimated at 150 tortoises per square mile (Woodbury and Hardy, 1948). Although 281 tortoises were marked, measurements are available for only 126 (Woodbury and Hardy, 1948; combination of Tables 1 and 2). Using the 126 tortoises as a sample, the population contained 90 percent adults, 9 percent subadults, 1 percent juveniles, and no tortoises in either the very small or hatchling categories. However, the authors noted that two live hatchlings and one very small individual were found (Op cit, page 165). If these three are included as part of the 281 marked in the study site, the composition of hatchlings and very small tortoises might be close to 1 percent.

There are two sources of information for computation of sex ratios. Woodbury and Hardy (1948, page 163) described the sex of 281 tortoises: 151 were females, 101 males, and 10 were undetermined. Using the figures 101 males to 151 females, the sex ratio is 66 males to 100 females (an estimate because sizes are not known). Different results are obtained by using the data from the 126 individuals in Tables 1 and 2; the sex ratio of adults and subadults is 133 males to 100 females.

Since the Woodbury and Hardy study, there has been additional work by Hardy (1976) and by Coombs (undated M.S.). Coombs (undated M.S.) found only 52 tortoises between 1972 and 1974, many of which were adults. The sex ratio of the 52 was 233 males to 100 females. No data were presented on size structure of the population. Both Coombs (undated M.S.) and Hardy (1976) suggest that the population has seriously declined since the 1940's and cite collecting and grazing as causes. Hardy (1976) discusses general habitat deterioration, destruction of dens, and loss of forage as continuing problems.

USE OF SIZE CLASSES TO ANALYZE POPULATION CONDITION

To date there are four areas in California, Nevada, and Utah where populations of desert tortoises have been examined. Some data on age structure, sex ratios, and density are available for each site (Table 1). The four tortoise populations should show some similarities and differences. Similarities might be expected in size or age structures and sex ratios. Differences would naturally occur in densities from area to area. Disturbances to populations from vandalism, collections and habitat deterioration would probably exert additional influences on population characteristics.

Similarities and Differences in the Size or Age Class Composition. Three of the desert tortoise study sites show similar data for age and size structure (Table 1). Salt Wells Valley, the Desert Tortoise Natural Area, and the Arden study area have populations composed of 42 to 58 percent adults, 14 to 17 percent subadults, 18 to 33 percent juveniles, 5 to 10 percent very small tortoises, and 1 to 2 percent hatchlings. The single exception is the Woodbury-Hardy study area, which had a

Fig. 1. The potential effects of collecting on size or age class composition of desert tortoise populations

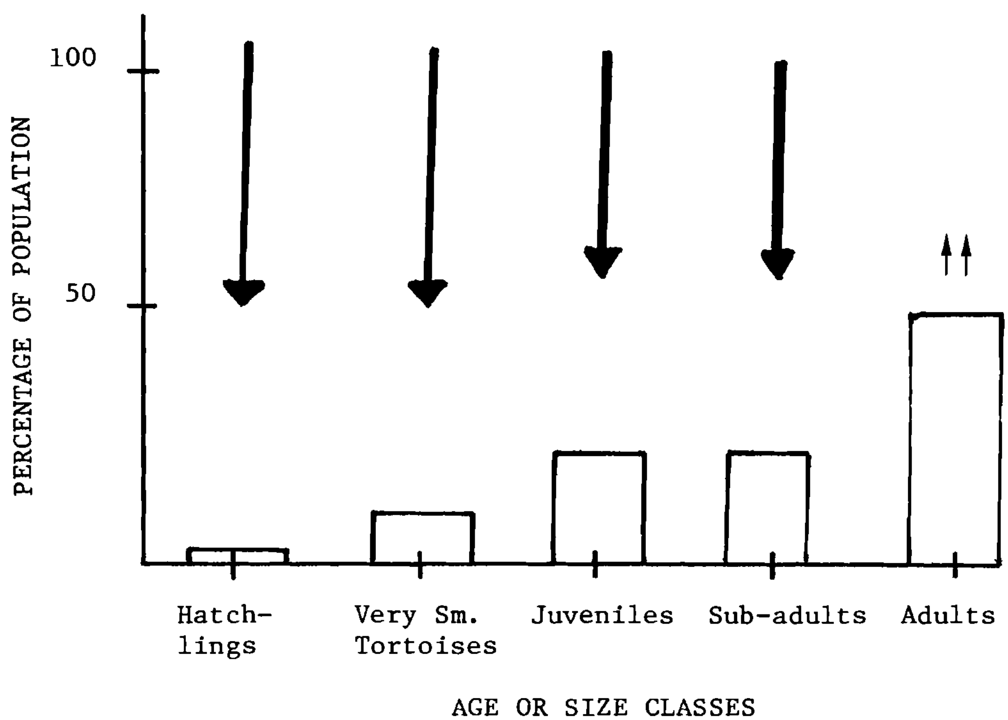

Fig. 2. The potential effects of livestock grazing on size or age class composition of a desert tortoise population

TABLE 1

A COMPARISON OF SIZE OR AGE CLASSES, SEX RATIOS,
AND DENSITIES IN FOUR POPULATIONS OF THE DESERT TORTOISE

Population	Sample Size	Size or Age Classes (%)					Ratio of Adults: Non-Adults	Sex Ratio (adults & subadults)	Density (# per. sq. mi)	Types of Habitat Disturbance
		Adults	Sub-Adults	Juve.	Very sm. Tortoise	Hatchl-ings				
Salt Wells Valley, San Bernardino Co., CA	48	58	17	19	5	2	140:100	39m:100f	9	roads, collecting
Desert Tortoise Natural Area, Kern Co., Ca.	103	42	14	33	10	2	72:100	87m:100f	est. 150-200	roads, collecting vandalisms, mining, livestock grazing, off-road vehicles
Arden Study Area, Nevada	119	55	17	18	10	1	120:100	136m:100f	86-102	collecting?
Woodbury-Hardy Study Area (1936-46), Washington Co., Utah	126 and 281	90	9	1	0 (.4%)	0 (.7%)	905:100	133m:100f 66m:100f	150	collecting, livestock grazing
Woodbury-Hardy Study Area (1972-74)	52	mostly adults						233m:100f		collecting, livestock grazing

population of 90 percent adults and very few hatchlings, very small tortoises, and juveniles. The ratios of adults to nonadults is similarly aligned for the 4 populations. Salt Wells Valley, the Desert Tortoise Natural Area and the Arden study areas have an almost 1:1 ratio of adults to nonadults, whereas the Woodbury-Hardy study population had a ratio of 9:1.

There are several possible reasons for differences between the Woodbury-Hardy population and the other three sites. Two are immediately obvious: the methods of study; and population condition. The methods of study employed by Woodbury and Hardy emphasized collections of tortoises from dens during fall and winter. This could have biased the sampling in favor of large individuals living in dens. The very small tortoises may not occupy dens but live in small individual burrows. In California, small tortoises live in individual burrows and do not share dens with adults (Berry, 1974b; 1975a). If, however, the 90 percent figure for adults represents the actual situation existing in the 1930's and 1940's, the high percentages of adults may indicate that there were serious problems with reproduction and survival of the young age classes 30 to 40 years ago. It is tempting to speculate that livestock grazing from 1870 to 1935 had already begun to influence population composition, and declines may have been underway ay for several years.

Size Structure in Undisturbed Populations. With the data available now, one might expect that relatively undisturbed populations of desert tortoises should have age or size class structures similar to the populations of Salt Wells Valley, Desert Tortoise Natural Area, and Arden study area. Although these three populations have experienced some disturbances, the size or age class compositions are close. The data are also close to the size class composition for an undisturbed population of the chuckwalla lizard, a long-lived desert herbivore like the tortoise. Chuckwalla populations at one site in California had 60 to 74 percent adults and 0 to 6 percent hatchlings (Berry, 1974a). Thus we might predict that an undisturbed population of tortoises would have a composition of 0 to 3 percent hatchlings, 5 to 10 percent very small tortoises, 15 to 25 percent juveniles, 15 to 20 percent subadults, and 45 to 60 percent adults. As more data are accumulated, scientists may be able to predict the range of values for each size or age class more closely.

In undisturbed populations, the size or age class composition of adults, subadults, and juveniles should remain fairly constant over time. Percentages of hatchlings and very small tortoises are likely to vary annually because young are not produced every year. Figures averaged for decades or centuries should be constant, however. This stability or potential for stability of tortoise populations is characteristic of species with great longevity, a long generation time, few offspring, and a long period to sexual maturity. The ability for such populations to grow and increase rapidly is very low.

Effects of Collecting and Habitat Deterioration on Size Class Composition. Collecting, vandalism, and habitat deterioration can alter size or age classes. In particular, collecting is likely to have impacts on the more mobile and obvious members of the population, adult males and females. Indeed, desert visitors and collectors report very few observations of young individuals. Removal of the larger tortoises will have a depressing effect on the subadult and adult age classes (Figure 1). If a population is subjected to substantial or low level, long-term collections, the ratio of adults to nonadults is likely to shift from 1:1 to a fraction thereof. Juveniles and very small tortoises will compose greater percentages of the population during initial phases of collections.

There are several sources of habitat deterioration (roads, mining, grazing, off-road vehicles, etc.) and each can have different impacts on a population. Livestock grazing has some well-defined impacts on desert tortoise habitat and predictions can be offered on the long term effects of grazing. Livestock grazing alters habitat by: reducing the density and diversity of annual wildflowers, annual and perennial grasses, and perennial shrubs; disturbing soil surface; and trampling shallow burrows. In addition, livestock can trample small tortoises. Probably the greatest conflict is the competition for forage between livestock and tortoises. Desert tortoises eat annual wildflowers and grasses, primarily in spring (Berry, 1974b, 1975ab). Annuals and grasses are also favored for livestock forage in spring.

If forage is reduced and nutritional quality lowered, female tortoises will have problems with clutch production. (That breeding success is intimately associated with quality and quantity of food available is well documented (Mayhew, 1968, pages 267-8).) Fewer clutches will be produced, and the younger age categories will diminish. In addition, reduction in forage will suppress growth in individuals, diminish activity, and generally decrease the abilities of tortoises to maintain natural behaviors. These effects have been described in other reptiles (Mayhew, 1968; Berry, 1974a).

Figure 2 outlines the probable effects of reduction in forage on a tortoise population. Production of hatchlings, small tortoises and juveniles will decrease, gradually lowering the percentages of the nonadult size classes in the population. After many years, the population will contain primarily adults. This may be precisely what has occurred at the Woodbury-Hardy site.

Sex Ratios. To some extent, there are similarities in sex ratios in all the populations (Table 1). Two, Salt Wells Valley and the Desert Tortoise Natural Area, are slightly skewed in favor of females. The Arden study area is biased in favor of males, and the Utah study area (in 1946) showed varying results, depending on the method of calculation. All are close to a 1:1 sex ratio, however.

Since the 1940's, the Woodbury-Hardy study population has undergone a radical change in sex ratios. There has been a shift from 66 males to 100 females (or 133 males to 100 females) in 1946 to 233 males to 100 females in 1974. Coombs (undated M.S.) and Hardy (1976) have cited disturbances from collecting and livestock grazing as causes.

Livestock grazing and the resulting loss of forage and habitat deterioration can cause differential sex mortality. Lack of forage would have a greater impact on reproducing adult females than on males. Egg production is risky when forage availability is doubtful. A female producing eggs in May, June and July would be spent, and would have fat reserves exhausted during the dry summer months and winter hibernation. She would have to survive from June to March on dry grasses and annuals, and hopefully would replenish fat reserves the following spring. If the following spring is dry and few annuals are available, survival becomes increasingly difficult. In contrast, males don't exhaust fat reserves through egg production.

FUTURE RESEARCH PROJECTS

Future research should concentrate on: establishing new study areas for long-term research projects on population characteristics of tortoises; determining the effects of different kinds of impacts on populations; evaluating minimum forage requirements for reproducing females; and delineating forage values of annual wildflowers and annual and perennial grasses. Further examination of the recent literature on sex ratios would be valuable, especially sex ratios in long-lived animals.

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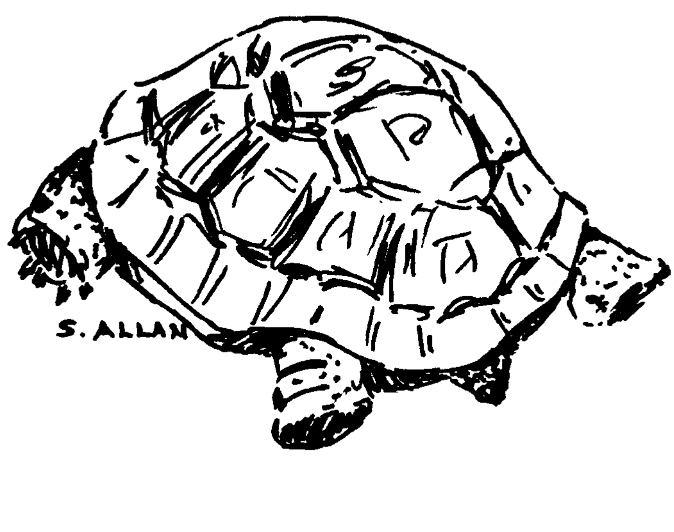

Population Density, Structure and Feeding Habits of the Desert Tortoise, *Gopherus agassizi*, in a Low Desert Study Area in Southern Nevada

B. L. Burge and W. G. Bradley

Population density, structure and feeding habits were determined for a desert tortoise population near Las Vegas in southern Nevada. The Arden Study Area, approximately 303.5 ha of flat desert, is covered by desert shrub vegetation characteristic of the lower elevations of the northern Mojave Desert. From May, 1974 through October, 1975, 126 tortoises were captured, marked and released. The number of recaptures totaled 696, exclusive of tortoises with transmitters. Population in the study area estimated by five methods, ranged from 36-44/km^2. Population age-size structure based upon total number of marked individuals plus known deaths within the period of study was as follows: hatchlings, 1.5%; very young individuals (<100mm), 12%; juveniles (100-179mm), 19.6%; subadults (180-214mm), 16.5%; and adults (>214mm), 50.4%. The relatively low percentage of adults is probably indicative of removal by man. The subadult - adult sex ratio--134 males:100 females--shows a higher proportion of males than has been reported for the few populations studied in other areas. During one complete active season, March through October, 1975, the frequency of use of each plant species was estimated from 100 direct observations of feeding tortoises. Of the 17 species utilized, the annual forb, *Plantago insularis*, was the major food item (frequency of use = 34%). It was eaten while green early in the season and in a dry condition later in the season. The shrub, *Sphareralcea ambigua*, desert mallow, was the other major food item eaten throughout the season (frequency of use = 27%). The remaining 15 forage species included a variety of forbs, grasses and shrubs.

The few available studies concerned with different aspects of life history of the desert tortoise, *Gopherus agassizi*, have varied considerably in scope. Several have dealt with captives. For the most part, the few investigations of free-living tortoises have been carried out in states adjacent to Nevada (Berry, 1974a, 1974b, 1975a, 1975b; Bogert, 1937; Grant, 1936, 1960; Miller, 1932, 1955; McGinnis and Voigt, 1971; Patterson and Brattstrom, 1972; Voigt, 1975; and Woodbury and Hardy, 1948). A study of growth of desert tortoises confined to outdoor enclosures is the only study dealing with Nevada populations (Medica, et al., 1975).

A study of home range, activity patterns and related aspects of life history of the desert tortoise, *G. agassizi*, was initiated in May 1974, and terminated at the end of October, 1975. During the 188 days spent in the field 126 individual tortoises were marked and released. Major emphasis during the study was placed on radio tracking of six to ten individuals. Additional data were obtained from 696 recaptures of the remaining individuals. The information regarding population density and structure presented and discussed in this paper was based upon data secured during the entire study. The information regarding feeding habits was based upon one complete active season, March through October, 1975.

DESCRIPTION OF THE STUDY AREA

The Arden Study Area, elevation 820 m, is located 16 km south and 11 km west of Las Vegas, Clark County, Nevada and approximately 150 m south of State Highway 16. Contiguous portions of Section 20, 21, 28 and 29, T22S, R60E, constitute an area 2.4 x 1.2 km, consisting of approximately 305.5 ha of alluvial fan sloping eastward (2-4%) from near the base of the Spring Mountains. Principally limestone derived, the Zonal Red Desert soil is composed of varying amounts of gravel, fine sand, silt and clay (U.S.D.A., 1967). Sizeable portions are covered with well developed desert pavement. Numerous stream channels of various dimensions transect the area, west to east. The larger channels expose calcic horizons, and along the banks, discontinuous exposures of cemented gravels contain karstic cavities which function as cover sites for tortoises and other animals.

The following climatological data are from the U.S. Weather Bureau, recorded for the period 1937 through 1975 at McCarran International Airport, elevation 658.5 m, located 9.7 km east and 6.5 km north of the Arden Study Area. Mean minimum and maximum temperatures of 0.3 C and 39.9 C occur in January and July, respectively. Snow is rare and persists for only a few hours. Rains are erratic in occurrence, both temporally and spatially, but occur mainly between July and March. The mean annual precipitation is 100 mm; however, the rainfall which occurs during late fall and winter is critical for the development of those winter annuals which become the food source for successful reproduction in a variety of desert animals (Beatley, 1969a, Bradley and Mauer, 1973; Zweifel and Lowe, 1966; Hoddenback and Turner, 1966). Although the relationship of reproduction to precipitation has not been analyzed for the desert tortoise, Medica et al (1975) reported a positive correlation between rainfall and tortoise growth. The average rainfall for November through February is 40.2. Vegetational analysis was carried out in the spring of 1968. Autumn and winter rainfall for 1967-68 totaled 64.2 mm and for 1974-75 totaled 37.2 above average for both the period of the tortoise study and the vegetational study.

Vegetational analysis of the shrub and understory layers is given in Tables 1 and 2. Density values were determined for 50 randomly located 30 x 6 m belt transects. Along each transect, cover and frequency of shrubs were determined by sampling successive M^2 plots at 6 m intervals. Relative cover, frequency and density were summed for each species to provide an importance value (see Table 4).

The study area is dominated by low desert shrubs (<3 percent cover) typical of southern Nevada. Among the principal species are bursage, *Ambrosia dumosa*, creosote bush, *Larrea divaricata*, range ratany, *Krameria parvifolia*, Nevada joint-fir, *Ephedra nevadensis*, and California buckwheat, *Eriogonum fasciculatum*. A number of herbaceous species make up the understory which varies greatly in species composition and abundance from year to year depending upon climatic patterns (Beatley, 1969b). Annual plant cover varies from 0.5 to 1.0 percent and occasionally as high as 4 percent. Several annual species are present each spring, in particular, common plantain, *Plantago insularis*, and pebble pincushion, *Chaenactis carphoclinia*.

Table 1. Vegetational analysis of shrub layer in the Arden Study Area, spring, 1968

Species	% Cover	% Freq.	Density M^2	IV*
Ambrosia dumosa	1.10	15.8	56.7	124.0
Larrea divaricata	0.47	9.3	16.0	52.1
Krameria parvifolia	0.32	5.4	12.5	34.6
Ephedra nevadensis	0.25	4.0	14.0	30.1
Eriogonum fasciculatum	0.26	3.2	6.4	22.1
Dalea fremontii	0.21	1.4	2.2	12.6
Yucca schidigera	0.11	0.5	1.3	6.0
Acacia greggii	0.08	0.8	0.9	5.5
Encelia virginensis	0.01	0.4	0.9	3.2
Machaeranthera tortifolia	<0.01	0.4	2.2	3.1
Gutierrezia sarothrae	0.01	0.3	1.8	2.6
Sphaeralcea ambigua	<0.01	0.2	1.0	1.5
Opuntia acanthocarpa	0.01	0.1	0.6	1.1

*Species with importance values <1.0 are listed in descending order as follows: *Psilostrophe cooperi, Opuntia basilaris, Salazaria mexicana, Echinocactus polycephalus, Stephanomeria pauciflora, Echinocereus englemannii, Opuntia echinocarpa, Opuntia ramosissima, Prunus fasciculata.*

Table 2. Vegetational analysis of understory layer in the Arden Study Area, spring, 1968

Species	% Cover	% Freq.	Density M^2	IV*
Plantago insularis	0.59	97.9	142.4	150.7
Chaenactis carphoclinia	0.05	73.2	9.4	24.1
Lepidium flavum	0.05	49.2	16.6	22.9
Eriogonum deflexum	0.06	55.7	10.0	22.1
Bromus rubens	0.03	34.0	9.1	14.3
Mentzelia tricuspis	0.02	25.8	4.7	9.4
Cryptantha micrantha	0.02	26.9	4.2	9.4
Hilaria rigida	0.06	8.7	0.6	8.4
Pectocarya recurvata	0.01	21.1	3.5	6.9
Phacelia crenulata	0.01	23.5	1.0	6.2
Chorizanthe rigida	0.01	21.9	1.0	5.5
Festuca octoflora	<0.01	22.6	1.4	5.5
Descurainia pinnata	<0.01	10.8	1.3	31.
Thelypodium sp.	0.01	7.1	0.9	2.9
Gila leptomeria	0.02	11.0	0.7	2.7
Eriogonum inflatum	0.01	2.8	0.1	1.7
Eriogonum sp.	0.02	6.7	0.2	1.6
Gilia setosissima	<0.01	5.6	0.2	1.3
Eschscholzia glyptosperma	<0.01	3.7	0.2	0.9
Streptanthella longirostris	<0.01	2.8	0.1	0.7

*Importance value

Ecological studies, first initiated on the Arden Study Area in 1967 by W. G. Bradley, have continued intermittently to date. Since 1972 the environment and adjacent to the study area has deteriorated somewhat due to the use of off-road vehicles and deposition of litter. At present, privately owned portions, approximately 50 percent, are interspersed with those managed by the Bureau of Land Management.

Although there has been no grazing or development on the site, several homes have been built within 800 m of two of the boundaries. Despite some encroachment, the present study was initiated after preliminary investigation indicated that most of the habitat destruction was peripheral to the study site and that tortoise density would be adequate for the purpose of the study.

METHODS

Population Density. Most visits to the study area were made at one to three-day intervals and involved five to seven hours of field work. In addition to radio-tracking selected individuals, every effort was made to mark all tortoises utilizing the study area and recapture each as many times as possible. Marking consisted of filing notches on a combination of marginal laminae which corresponded to a numbering system. The assigned number was also written across one or two anterior and posterior marginals using yellow acrylic paint or black water proof ink.

Daily priority was given to observing tortoises with transmitters before, during and after their morning or afternoon activity period; therefore, most opportunities for marking and recapturing the other tortoises occurred while in transit between transmittered tortoises and after most tortoises had sought the cover of burrows. Knowing the location of these burrows increased capture success during this period of the day. To effect this, the study area was thoroughly searched and more than 700 burrow locations plotted. Burrows were checked for occupants at intervals ranging from twice daily to twice monthly. All captive locations were plotted. Search routes included periodic deviations of 6-8 m from the shortest distance between consecutive burrows. These deviations were usually sufficient to reveal newly dug or previously unmapped burrows. The use of plotted burrow sites was considered an effective means for locating tortoises because of their high degree of repeated use of burrows and old burrow sites both within the season and from season to season.

Population density was estimated by five methods.

1. The first was based upon the total count of marked individuals. Since the resulting estimate would undoubtedly represent less than the actual population, all live marked plus mortalities known or estimated to have occurred within the period of study were included. A conservative estimate of the time since death was based upon the condition of the remains. The remaining four methods involved statistical analysis utilizing data for live animals only.

2. The Schnabel method involved successive sampling periods of approximately equal divisions of total field time.

3. The Lincoln Index was calculated from the final period. Graphic methods involving linear regression included.

4. Plotting captures against previously marked individuals (Hayne, 1949).

5. A method described by Marten (1970) which attempts to correct for unequal "catchability" of any subgroup within a population. This heterogeneous condition may operate initially and subsequently as a result of capture. Tortoises <100 mm (carapace length) appeared to be in this category. Except for this last method, density figures for individuals <100 mm were treated separately from those >100 mm.

Each captured individual was considered to be a resident although the home range of several probably extended outside the study area. To accommodate this situation in calculating the density the results from each of the above methods were applied to an area equal to the study area plus a boundary strip.

Whereas the study area was bounded on three sides by >1000 m widths of disturbed habitat (homes, access roads and areas of intense off-road vehicle use) which showed little or no tortoise sign during the period of the study, the border strip was calculated only for the fourth side. The calculated strip was equal in width to one-half the mean diameter of the average home range (Dice, 1938). Using a convex polygon method, home range was determined for one juvenile and for ten adults (6 males, 4 females). Each was captured 26 to 217 times ($\overline{x}$ = 114) over a period of 12-18 months. It was important to delineate a home range by using recapture points made over a full, active season because a home range was not fully utilized during any smaller time interval. Numerous recaptures over less than a full season would not have indicated the size or extent of the home ranges. The mean home range area of males was larger than that of females but not significantly ($P>.05$). One mean home range diameter was calculated from the ten adult values and applied to the number of individuals <179 mm. Although only one juvenile home range was determined, it was significantly smaller than that of adult females ($P<0.01$) and considered to be the best available value for individuals between 100 and 179 mm as well as for individuals <100 mm. The censused study area of 303.5 ha was increased for computational purposes to 317.5 ha for individuals 100 mm and to 374 for individuals >100 mm.

Population Structure. Initially and at each recapture, shell dimensions were measured. Mid-dorsal carapace length was measured to the nearest millimeter from the anterior.margin of the precentral lamina to the most posterior margin or projection of the carapace. Unless otherwise stated, all future references to measured size refer to carapace length. Sex could usually be determined for tortoises having attained 180 mm. At this length in males, the plastral concavity in the area of the femoral laminae is poorly to moderately well developed.

Each individual was assigned to one of the following age classes: Adult, subadult, juvenile or hatchling. The hatchling class is composed of individuals hatched during the current active season. Distinguishing characteristics included the degree of umbilical protuberance, the persistance of the transverse plastral fold and the presence of only minor growth ridges, if any. Except for the smaller, obvious juveniles (immature) and larger obvious adults (mature), assignment to these two classes remains tentative. Presumably within the upper ranges of the remaining intermediate sizes there were individuals which had attained sexual maturity; however, for this species there are as yet no reliable indirect means for distinguishing large immature individuals from small, sexually mature individuals. Individuals of intermediate size and degree of differentiation of secondary sexual characteristics which could not be assigned definitely to either group, were grouped separately as subadults. Stickel (1950) used the term "intermediate" for a comparable group of box turtles, *Terrapene carolina*. Minimum subadult size of the desert tortoise was set at 180 mm.

For the adult, mean minimum size at sexual maturity remain undetermined; however, the processes of sexual maturation are broadly related to the termination of the period of rapid growth typical of young individuals. For reptiles, in general, this period of rapid growth is followed by a prolonged period in which growth continues at a much slower and often intermittant rate. Investigating free-living *G. agassizi* in Utah, Woodbury and Hardy (1948) reported that a marked reduction in growth rate with subsequent slow growth occurred for females at 230 mm and for males at 250 mm carapace length. An indication that the minimum length at sexual maturity for females in that population was even lower was evidenced by one 217 mm individual, remeasured at 218 mm after more than 25 years (Hardy, 1972). Presumably, that female was sexually mature by 217 mm. Based upon Hardy's recapture data, Berry (1974) estimated 215-220 mm as minimum length at sexual maturity.

With these growth, size and sex relationships in mind, and the possibility that these relationships may vary from one geographic location to another, the criteria for adults in the Arden population were developed on the basis of comparative size, distinctness of secondary sexual characteristics, reproductive behavior and degree of shell wear. At the end of the 1975 active season, one judged optimal for growth, the incidence of growth and amount of increase in length were compared for 105 individuals ranging in size from 55-286 mm.

Both the incidence and rate of growth decreased markedly at about 214 mm in females and by at least 224 mm in males. No growth data were available for males between 215 and 224 mm. Sexual maturity was definitely indicated for one 220 mm female which produced a clutch of four eggs. For the Arden population the assignment of males and females to the adult class was tentatively based upon a minimum carapace length of 215 mm.

The separation of very young tortoises, <100 mm, from other juveniles was used by Berry (1974a) and is included for purposes of comparing population structure. The basis for this further division of juveniles is that 100 mm is the approximate length at which ossification of the shell is complete (Woodbury and Hardy, 1948; Grant, 1936). Implied at this stage of development is an increased margin of protection against predation.

Feeding Habits. Whenever a feeding tortoise was encountered, observations were recorded on the feeding behavior and the plant species eaten. The term "frequency of use" refers to the number of separate observations in which each species was eaten. A "feeding observation" was a discrete occasion in which feeding was more or less continual, and a varying number of plants of one or more species were consumed. In several instances, the species could not be determined due to the small plant size, 1-2 cm tall and the tortoise's complete consumption of the plant within a few seconds; and the sparse distribution of the individual plants involved.

RESULTS AND DISCUSSION

Population Density. During the period 4 May 1974 through 31 October 1975, 126 individuals estimated to have died during the period of the study were collected. two of which had been marked, therefore, the total count was 133. Density estimates are shown in Table 3.

Table 3. Comparison of population density estimates for desert tortoises on the Arden Study Area

	N/km^2			Study area totals		
	100mm	100mm		100mm	100mm	
Direct	32.0	5.7	37.7	97	17.2	114
Lincoln Index	31.8	9.5	41.3	97	28.7	125
Schnabel	27.3	8.2	35.5	83	24.8	108
Linear Regression						
(Hayne, 1949	31.8			97		
(Marten, 1970)	35.6	8.2	43.6	108	24.8	132

Estimated density using the four methods which included results for both small and large tortoises were similar, ranging from ca. 36-44/km^2. The Hayne linear regression method was not applicable for individuals <100 mm due to the small sample size and to the distribution of initial captures throughout the study. Due to the low detectability and resulting low sample size of individuals <100 mm, density estimates were more variable and probably less reliable than for tortoises >100 mm.

There are physical and behavioral characteristics of tortoises of all sizes which affect detectability. These include: 1) cryptic coloration; 2) tendency to halt in response to an upright person up to a distance of at least 100 mm, remaining in place for several minutes; 3) slow gait and therefore low level of stimulation to the human eye; 4) low profile and the effect of intervening vegetation obscuring the view as tortoise and/or observer moves through the desert shrub cover. These factors function to favor the detection of larger tortoises. Individuals <100 mm not only have a proportionately low detectibility but also had a disproportionately low rate of recapture. Possible explanations for this may include reduced fidelity to burrows and/or higher predation rate than for larger individuals. Individuals >100 mm continued to re-use the burrows in which they were captured; whereas capture burrows of individuals <100 mm rarely showed sign of reuse.

Because larger tortoises utilize certain burrows repeatedly and most recaptures were made at burrows, this might result in a substantial source of bias in the censusing method favoring the recapture of a given individual in a particular burrow. However, data from tortoises with transmitters indicated that an individual tortoise may re-use 12-25 burrows throughout a season with ca. 75 percent of these being used intermittantly by one or more other tortoises.

Population density of 36-44 km is probably lower than that found under pristine conditions due to both habitat alteration and removal of tortoises. A number of excavated burrows provided indirect evidence that tortoises have been removed by man. The potential for disturbance is considerable because of the proximity of the area to a major highway and to homes. Observed disturbances included off-road vehicle traffic and the use of firearms. The extent of population decrease is not known, but the nature and rate of the disturbances have been such that it is safe to assume that the Arden population is not one that has become stabilized. On the basis of land ownership patterns and encroachment, destruction of this particular area of this particular area of tortoise habitat is imminent.

Density estimated for the Arden population falls within the range of densities estimated for populations in California and Utah by Berry (1975a, 1975b) and Woodbury and Hardy (1948) shown on Table 5. However, these populations have been affected to different degrees by removal of tortoises and habitat disturbance of various kinds. Reliable densities taken before severe habitat alteration are not available. In fact, density estimates of undisturbed populations in representative habitats may no longer be available for comparison. Comparisons of density (or structure) between the unstable populations that exist are of limited value. More meaningful are the changes that occur within any one population and its habitat.

Population Structure. The age-size structure shown in Table 4 is based upon 133 individuals. For smaller, faster growing individuals lengths mid study period were used; however, except for one hatchling, there was no significant change in the population structure as a result of growth during 1975. The actual percentage of adults is probably less than the observed 50 percent because smaller individuals, especially hatchlings and very young (13.5%) are relatively more difficult to locate, hence, are underrepresented in percentage calculations. This point of view is supported by the densities estimated by methods other than the direct count for individuals <100 mm--8.2 and 9.5/km^2 or ca. 19 and 23 percent (Table 3). In a natural undisturbed tortoise population one would expect a higher percentage of adults (>50%) because of their long life span, low natality combined with greater potential vulnerability of very young animals to predation. Estimates of adult percentages have been reported for other long-lived terrestrial turtles inhabiting protected and/or relatively undisturbed habitats. They include: *Terrapene carolina* ca. 90 percent (Stickel, 1950); *Terrapene ornata* ca. 86 percent (Legler, 1960); *Gopherus berlandieri* 85 percent (Auffenburg and Weaver, 1969); *G. berlandieri* 85 percent (Rose and Judd, 1975). The direct and indirect effects of man are difficult to quantify; however, in time, removal of the more visable adults and subadults could account for the low percentage of adults in the Arden population.

The low number of hatchlings and very young individuals probably reflect, in part, the difficulty in finding them; however, natural environmental pressures, such as low and erratic precipitation patterns (Pianka, 1967) possibly inhibit reproduction as is true for other desert reptiles (Hoddenbach and Turner, 1966; Zweifel and Lowe, 1966). In addition, these variable and extreme climatic patterns resulting in the reduced forage availability would also decrease the chances for survival of younger animals. Furthermore, in years of low hatching success, predation may account for loss of most young of the year.

Comparisons of population structure, sex ratios and densities for desert tortoise populations in California, Nevada and Utah are shown in Table 5. The structure of the two California populations studied by Berry (1974a, 1974b, 1975a, 1975b) is quite similar to that of the Nevada population although densities differ considerably. One difference in structure is evident in the Western Rand Mountains' population which has a somewhat higher percentage of juveniles and lower percentage of adults than the other two populations. The adult percentages for these three populations differ considerably from the much higher percentage estimated for the population in Utah studied by Woodbury and Hardy (1948). They pointed out that prior to and during their ten-year study, tortoises were subject to removal for commercial purposes and to the potential hazards of trampling and competition for forage from livestock. In any population, removal would be expected to reduce the number of larger more visable individuals; the latter factors may be more critical to the survival of smaller individuals.

The adult male to adult female sex ratios for the two California and one Nevada populations do not differ significantly from an expected 1:1 ratio ($P>.05$); however, turtles are among those reptiles that show deviations from the expected 1:1 sex ratio (Auffenberg and Weaver, 1969; Forbes, 1940; Hildebrand, 1932; Legler, 1954; Risley, 1933; and Tinkle, 1958). In the above studies females outnumbered males 1.6:1 to 6:1. The same trend was found in the two California populations. If an imbalance in sex ratio with a higher proportion of subadult and adult females is found to be a natural characteristic of desert tortoise populations, the greater proportion of males in the Nevada population might then be significant.

Table 4. Age-Size structure and sex ratios for desert tortoises in the Arden Study Area for the period October 1974 through October 1975.

Age-Size class (range of carapace length in mm)	Size range observed	Sex			Total number in each class	% of Population
		Males	Females	Unknown		
Hatchling	45			2	2	1.5
Very Young - 100	55 - 98			16	16	12.0
Juvenile 101 - 179	105 - 179	1	1	24	26	19.6
Subadult 180 - 214	182 - 214	11	11		22	16.5
Adult 215 -	215 - 286	40	27		67	50.4
	Totals	52	39	42	133	100.0

Sex ratio (males:females)

Subadults	100:100
Adults	148:100
Subadults and adults	134:100

Table 5. Age structure, sex ratio and estimated density for desert tortoise populations in California, Nevada and Utah.

Age-Class	Estimated percentage of population			
	California		Nevada	Utah
	Naval Weapons Center CT-4[1]	Western Rand Mountains[3]	Arden Study Area	Study Area Beaver Dam Slope Population
Hatchling	6.7[2]	1.9	1.5	
Very Young		9.7	12.0	
Juvenile	18.8	33.0	19.6	
Subadult	16.6	13.6	16.5	
Adult	58.3	41.7	50.4	95.0[5]
Estimated density (N/km^2)	3.5	58-77	36-44	62
Sample size	48	103	133	281
Sex ratio and N♂♂:♀♀				
Subadults and adults	38.5:100(10:26)	87:100(26:30)	134:100(51:38)	
Adults	47:100(9:19)	72:100(18:25)	148:100(40:27)	

[1]Berry (1975a)

[2]Ibid., hatchling and very young, combined.

[3]Berry (1975b).

[4]Woodbury and Hardy (1948).

[5]Based upon minimum carapace lengths of 230mm for females and 250mm for males.

Feeding Habits. Feeding habits were determined from observation of thirty individuals on 118 feeding occasions from April through October, 1975. Feeding duration varied between less than one minute to thirty minutes. The frequency of use of each plant species is shown in Table 6. Most of the feeding observation (93)) occurred from May through September. The low number of feeding observations in April and October reflected the generally low level of activity. Below normal daytime temperatures through most of April resulted in minimal tortoise activity until the last week of the month. In October, a sudden decline to below average temperatures occurred at the end of the first week, after which tortoise activity was greatly reduced.

Based upon 100 feeding observations, tortoises were found to utilize 17 plant species. These included five forbs, three grasses and nine suffrutescent or woody shrubs. The major food items were the forbs: Common plantain, *Plantago insularis*, and rattlesnake weed, *Euphorbia albomarginata*, the grass six-weeks fescue, *Festuca octoflora*, and the desert mallow, *Sphaeralcea ambigua*. All four species were utilized throughout most of the period May through September. Frequencies of use for other species were low, ranging from 0.9 to 4.6 percent.

Some examples of utilization relative to seasonal availability are given below. Only the terminal growth (flower buds and stems) of *Opuntia ramosissima* were eaten, and these were available for a short time only in June and July. Although *Mirabilis* was available beginning mid-summer, it was uncommon and localized in distribution. The pads of *Opuntia basilaris* remained turgid throughout most of the season; yet, there was no evidence that tortoises continued to feed on them after May. *Plantago*, on the other hand, was eaten throughout the season, although the plants became dry by mid-June.

Winter rainfall (37.2 mm) had been sufficient to provide excellent potential for spring forage. An additional 37.2 mm fell in March and April. Below normal temperatures occurred through early June and prolonged the availability of green and succulent forage. On July 3rd heavy rains and extensive flooding produced renewed growth and second flowering of many perennials. A second crop of *Plantago* and *Festuca* provided green forage through most of July. The high number of feeding occasions observed in July apparently was due to the abundance of succulent forage as a result of the flood; however, that level of foraging activity probably was not typical for that time of the year.

The relationship between utilization for the season as a whole and availability on the basis of relative abundance (see Table 4) for shrub and understory layers is given in Table 7. Desert mallow with the highest frequency of use in the shrub layer (26.8%) ranked twelfth out of 24 in importance value. With the exception of range ratany, *Krameria parvifolia*, the remaining shrub species eaten had importance values of less than 1. Butterfly bush, *Gaura coccinea*, with a frequency use of 3.7 percent was the only shrub species utilized that was not recorded on the 1968 plant transects; in 1975, importance value was estimated at less than 0.1. Tortoises appear to be highly discriminating in their utilization of the shrub layer -- even after one eliminates species whose growth habit places most edible parts out of the tortoises' reach.

In contrast to the shrubs, the use of the understory shows a positive correlation to availability. Common plantain had a frequency use of 34.3 percent and an importance value of 151; six times greater than the second ranked species, *Chaenactic carphoclinia*, (IV = 24), which was not observed being eaten. Although species composition and abundance of winter annuals vary greatly from year to year, common plantain has been the most abundant annual species on the area each year since initiation of studies in 1967. Six-weeks fescue with the next highest frequency of use (6.5%) ranked twelfth of the twenty species in the understory layer; however, this species was considered to be more abundant in 1975 than estimated for 1968. Of the six food species not recorded for the understory in 1968, five had low frequency of use and all six were uncommon and/or very localized in 1975.

Based upon the 100 feeding observations, the understory layer had a total frequency of use of ca. 59 percent as compared to 41 percent for the shrub layer. Common plantain and desert mallow made up 61 percent of the total frequency of use. Both species were eaten throughout the season. With the exception of these two species, food habits of the tortoise appear to be generalized. Except for *Plantago* there was little relationship between use and availability. Species eaten by juveniles (82-157 mm) were included among those eaten by larger tortoises. The number of observations of feeding juveniles (six) was not sufficient to determine their food preferences.

Table 7. Relationship between availability expressed as importance value (IV) and percent frequency of use of plant species eaten by desert tortoises in the Arden Study Area April through October, 1975

Species	Common Name	IV[1]	% Total Freq. of use
SHRUB LAYER			
Sphaeralcea ambigua[1]	Desert Mallow	1.5	26.8
Opuntia ramosissima[2]	Pencil Cholla	0.1	4.6
Opuntia basilaris[3]	Beavertail Cactus	0.6	3.7
Gaura coccinea	Butterfly Bush		3.7
Krameria parvifolia[4]	Range Ratany	34.6	0.9
Stephanomeria pauciflora	Desert-Straw	0.2	0.9
Echinocactus polycephalus[5]	Cottontop Cactus	0.3	0.9
UNDERSTORY LAYER			
**Plantago insularis*[7]	Common Plantain	150.7	34.3
**Festuca octoflora*[7]	Six-Weeks Fescus	5.5	6.5
Euphorbia albomarginata	Rattlesnake Weed		6.5
Selinocarpus diffusus	Desert Wing Fruit		2.8
Eriogonum inflatum[6 7]	Desert Trumpet	1.7	1.9
Mirabilis froebelii	Ginat Four-O'Clock		1.9
Erodium cicutarium	Filaree		1.9
Allionia incarnata	Trailing Four-O'Clock		0.9
Hilaria rigida	Galleta Grass	8.4	0.9
**Bouteloua barbata*	Grama Grass		0.9

[1]Based upon 1968 vegetation analysis.
[2]Flower buds and new stem-tips only.
[3]Pads only.
[4]Flowers only.
[5]Fruits only.
[6]Stems only.
[7]Eaten in dry and green condition.
*Annual species.

Table 6. Frequency of use of plant species eaten by desert tortoises, as determined from 100 feeding observations, April through October, 1975. Plant parts eaten include flowers, stems and leaves, except as noted below.

Plant species	Apr.	May	June	July	Aug.	Sept.	Oct.	Total freq. of use	% Total freq. of use
Plantago insularis		9	5*	8*	7*	7*	1*	37	34.3
Sphaeralcea ambigua	1	3	7	14	3		1	29	26.8
Festuca octoflora	1		2*	3			1*	7	6.5
Euphorbia albomarginata		1	1	2	2	1		7	6.5
Opuntia ramosissima[1]			4	1				5	4.6
Opuntia basilaris[2]	1	3						4	3.7
Gaura coccinea		1	2			1		4	3.7
Selinocarpus diffusus		1		1	1			3	2.8
Eriogonum inflatum[3]	1					1*		2	1.9
Mirabilis froebelii					2			2	1.9
Erodium cicutarium		2						2	1.9
Krameria parvifolia[4]		1						1	0.9
Stephanomeria pauciflora		1						1	0.9
Echinocactus polycephalus[5]		1						1	0.9
Allionia incarnata				1				1	0.9
Hilaria rigida					1			1	0.9
Bouteloua barbata						1		1	0.9
Total frequency of use	4	23	21	30	16	11	3	108	
Total feeding observations	4	21	19	28	15	10	3	100	

[1]Flower buds and new stem-tips only.
[2]Pads only.
[3]Stems only.
[4]Flowers only.
[5]Fruits only.
*Dry plants eaten during part or all of month

It is highly probable that the tortoises utilized more of the spring-flowering annual species than the observations indicated, considering that more than 50 percent of the forage species listed had frequency of use of only one or two. At least nine additional species or closely related species that have been utilized by tortoises in California and Utah (Berry, 1974a, 1975b; and Coombs, 1974) occur in the Arden Study Area.

Tortoise feeding habits have been studied in southwestern Utah, northern Arizona and southern California. Woodbury and Hardy (1948) reported a limited number of feeding observations during fall and winter. Tortoises ate the perennial grass bush mahly, *Muhlenbergia porteri*, cheat grass, *Bromus rubens*, and the forb filaree, *Erodium cicutarium*. Based upon direct observation and scat analysis of the remnant population now occupying the same area, Coombs (1974) found cheat grass and filaree to be the major food items. Apparently, vegetative composition on the study area has changed considerably due to continued livestock grazing. As observed recently by Hardy (Berry, 1974b), the once common bush muhly has become rare.

Hansen, et al (1976) analyzed scats from two populations in northern Arizona and one from southwestern Utah. Grass comprised most of the diet, although species composition and utilization was significantly different between areas. This might have been related to differences in vegetative composition on the study areas. A wide variety of grass species were ingested by two Arizona populations, whereas in the Utah population a single species, cheat grass, made up 64 percent of the diet. The forb filaree was an important food item in the Utah population, whereas the shrub, globemallow, *Sphaeralcea spp.*, was an important item in one of the Arizona populations. The study by Hansen et al does indicate tortoise utilization of a wide variety of grasses and other plant species but does not indicate definite food preferences within a particular vegetation type.

In contrast to the above study, Berry (1974a, 1974b, 1975a) emphasized the importance of annuals, other than grasses, in the diet of desert tortoises in the northern and western Mojave Desert of California. Grasses were important in the diet, primarily when annuals became unavailable as the season progressed. Her findings were based upon observations of feeding throughout the activity season.

It appears that food habits of the desert tortoise vary considerably between populations which occupy desert areas with different vegetative composition. There are some indications of distinct food preferences and possible restricted options. The major food items included grasses, forbs and at least one shrub species. The remainder of the diets included a wide variety of plant species.

SUMMARY AND CONCLUSIONS

Findings from the study of desert tortoises on the Arden Study Area are summarized as follows:

1. Density estimates, using five methods, ranged from 36-44/km^2. These may represent under-representations because of the low visibility of individuals $<$100 mm.

2. The population structure of 50.4 percent adults is lower than expected for the species and may be a result of man's continued removal of larger, more visible individuals. The small number of hatchlings and very young individuals is probably due to a combination of low detectability, low natality and high predation rates.

3. Direct and indirect evidence suggests that females and possibly males are sexually mature at 215 mm carapace length.

4. Adult males outnumber adult females although not significantly ($P > .05$) from a 1:1 ratio. However, an unequal ratio may be typical and should not be ruled out. Those populations for which sex ratios have been reported all have been subject to human encroachment -- collecting and habitat alteration. These factors may have altered sex ratios.

5. Direct observations of feeding indicate that the primary food items are the annual, common plantain, and the shrub, desert mallow, both eaten throughout the active season. Secondary food items include a variety of forbs, shrubs and grasses.

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Preliminary Investigation of a Desert Tortoise, *Gopherus agassizi*, Population in Pinal County, Arizona

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The particular tortoise population being studied is located in the Lower Sonoran Desert Life Zone, which is characterized by hot summers and mild winters with large daily temperature fluctuations. Precipitation normals are approximately 20.32 cm (eight inches) per year, generally occurring during mid-winter and mid-summer. Negative precipitation departures from normal were noted for 1974 and 1975.

The topography in the area varies from alluvial basins, bajades and low rolling desert foothills to low desert, mountains. Small desert washes drain the area.

Preliminary vegetation studies indicate the characteristic overstory species in the area are triangle bur-sage, *Ambrosia deltoides*, brittlebush, *Encelia farinosa*, creosote, *Larrea divericata*, little leaf palo verde, *Cercidium microphyllum*, and saguaro, *Cereus gigantea*. Characteristic understory species are schismus, *Schismus arabicus*, filaree, *Erodium cicutarium*, desert mallow, *Sphaeralcea ambigua*, plantain, *Plantago spp.*, and wooly-daisy, *Eriophyllum lanosum*.

Twenty-three adult desert tortoises have been located, measured and tagged in approximately one square mile since August, 1975. The sex ratio of male to female tortoises is 1:1.3. One sub-adult was also located, measured and tagged. At this time no hatchling tortoises have been observed.

To determine the location of certain animals for subsequent study of movement and behavioral activities, three females and three males have been equipped with radio transmitters. The transmitters have a range of approximately one to two miles from the ground and up to ten miles from the air. The life span is projected to be two years with the lithium chloride batteries. A directional yagi antenna is used to precisely locate the instrumented animals. An adult female tortoise was recently equipped with a temperature sensitive internal implant as well as a temperature sensitive external transmitter. It is hoped that optimum temperature requirements for activity as well as external and internal temperature gradients can be determined.

Three permanent tortoise hibernacula have been located to date. In addition, numerous temporary, shallow burrows are scattered throughout the study area. The burrows are not readily visible as they are hidden either by dense vegetation or rock piles. Burrows are located by tracking radio-equipped animals. Many more new animals will probably be located in the area during the spring, summer and fall of this year.

Human usage in the area consists of mining, livestock grazing, hunting and "rock-hounding". At this time mining interests in the area pose little danger to the tortoise population. Mining personnel remove tortoises from mining holes and discourage tortoise collections by tourists and collectors. The cattle ranching interests in the area may have some (as yet undetermined) affect on the population. There are at least two known instances of tortoises being removed from the study area by hunters and "rock-hounds" and undoubtedly there are some additional losses due to these factors.

Tortoise densities in this isolated area have not been quantitatively determined at this time. However, estimates from captures made in the area and statements from the mining personnel indicate that densities may exceed fifty per square mile.

Predation on tortoises from wildlife in this area is unknown. No instances have been observed and no shells or pieces thereof have been located. It is known, though, that the area contains coyote, fox, bobcat and mountain lion; the former three in abundance.

Research emphasis will center on location of egg-laying areas and nests, daily activities and movements, food utilization and the impact of man on the tortoise population.

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Vocalization in the Desert Tortoise

Robert Patterson

Vocalization in the desert tortoise, *Gopherus agassizi*, may elicit the following behaviors: (A) Hisses emitted by startled tortoises or males engaged in aggressive interactions may produce listening or flight behaviors in other tortoises. (B) Long calls if emitted by subordinate males in aggressive encounters may elicit feeding or flight responses in dominant males. (C) Pops and poinks may cause flight and in a few cases may cause dominant male assistance for overturned males.

Earlier studies have shown that *Gopherus agassizi* has a social structure that is a loose, dendritic, male hierarchy (Auffenberg, 1969; Brattstrom, 1974) and aggressive behavior is used to establish dominance. During an observation of male aggressive behavior, vocalization was noted, raising the question of its possible behavioral and communicational role.

Studies have shown that tortoises vocalize (Campbell, 1967; Campbell and Evans, 1967; Miller and Stebbins, 1964; and Nichols, 1953) and that they appear to hear. Actual hearing ability in tortoises has been demonstrated both physiologically (Adrian, Craik and Sturdy, 1938) and behaviorally (Gadow, 1901; Van Denburgh, 1914: Patterson, 1971).

Because of this earlier work, an attempt was made to record the full range of vocalization behaviors in the captive herd of desert tortoises. Their vocalizations were recorded in isolation, during feeding, when startled at night and during mating and aggressive encounters. Vocalizations were also recorded when the captive herd was presented with a motorized dummy shell equipped with a speaker. The dummy shell was wiped with the water soluble material obtained from dominant male shells and vocalizations were played back to the herd through the speaker mounted in the shell. All behaviors of the herd were noted including any vocalizations. The motorized shell was used to engage other tortoises in aggressive encounters and was overturned following dominant male aggressive encounters and vocalizations were played back through its speaker.

All recordings were made using a portable field recorder (Uher-4000 report S) and were analyzed using a Kay Electronic Sonagraph.

Vocalizations obtained from the herd include pops, whoops, huhs, huh-huh-whines, echs, hisses, grunts, bips and long calls. The vocalizations were named by their apparent sound to the human ear. Outlines of typical sonographic records showing vocalizations are shown in figures 1 and 2.

When vocalizations were played back to the captive herd, if the signals continued for any length of time or were repetitive, the tortoises appeared to lose interest rapidly. When vocalizations were played back through the dummy shell, hisses often caused the females to leave the area and the males to turn away from the dummy shell.

When the dummy shell engaged the dominant tortoise and was overturned, emitting vocalizations from its speaker, all of the tortoises either left the area or faced away from the shell.

On several occasions following aggressive encounters between males of the captive herd, if the overturned tortoise extended its neck and emitted a poink call, the dominant tortoise assisted in righting the subordinate tortoise. The neck extension and vocalization by the overturned tortoise often produced feeding behaviors in the dominant male ending aggression which may be a form of displacement behavior (Bastock, 1967). It should also be noted, however, that it is not unusual for aggresive males to right overturned subordinate males by repetitive ramming when no vocalization has occurred. This usually takes place early in the spring when the males are very aggressive and continue aggressive encounters much longer than at any other time of the year.

As shown in Table 1, tortoise vocalization seems to be situation determined and of a communication type that carries very little information content. When analysis of the vocalizations was attempted using other animal classification systems, they appear to fit distress, threat and predator calls of birds (Collias, 1960; Bushnell, 1963); the grunt and the huh-huh-whine calls being exceptions and appear to match the crowing calls of birds. This tends to support the idea that the signals have low information content compared to bird or mammal calls. To date, vocalization activity has only been noted during daily activity periods and when the temperature has been between 21° C and 30° C.

Frequency of vocalization appears to drop off very rapidly with familiarity in a captive herd, increases slightly with introduction of new members and then falls again as aggressive behaviors also fall.

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TABLE 1.___Sex, Age Group and Behavior Eliciting a Given Type of Vocalization

Tortoise Age	Observational Sequence	Vocalization and Behavior Resulting from Vocalization
Adult	Mating	Male - grunts with each swing
		Female - hisses just after male upswing
	Overturned	Long call, whoop, bip, ech
	Grabbed asleep	Grunt, ech, pop, bip, hiss, long whoop, huh-huh-whine
	Calls recorded and played back	Hiss, pop, ech, whoop, long call - all leave area
	Dummy shell - play back of calls	Pop, ech, whoop, long call - all leave area
Adult	Aggressive -	
	Combat	Hiss, grunts
	Upside down	Long call, hiss - dominant male feeds
		Poink - dominant male assists in righting
Juvenile	Upside down	Huh-ech

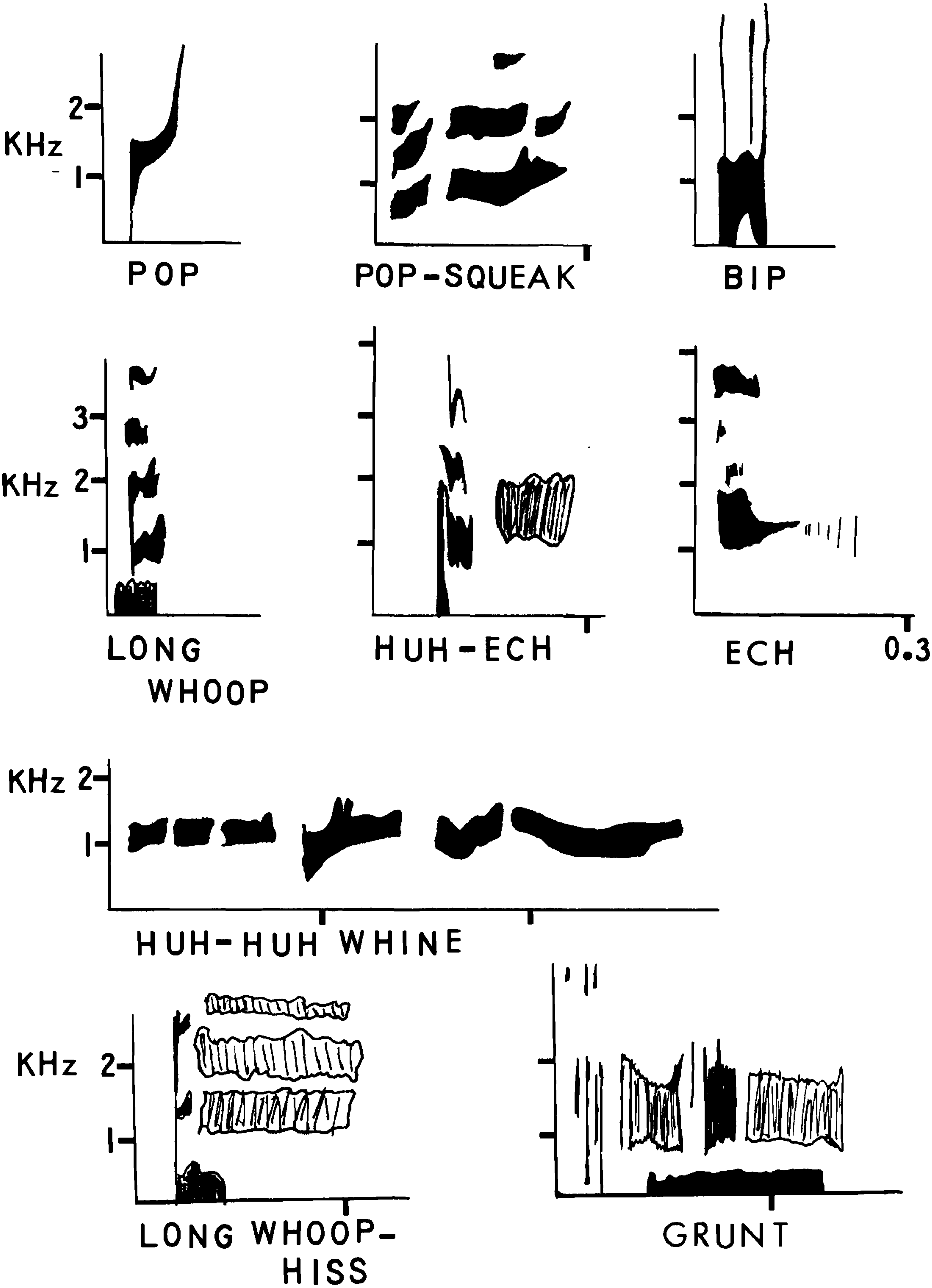

Figure 1. Outline of Sonograms of Typical Vocalizations Obtained from the Desert Tortoise.

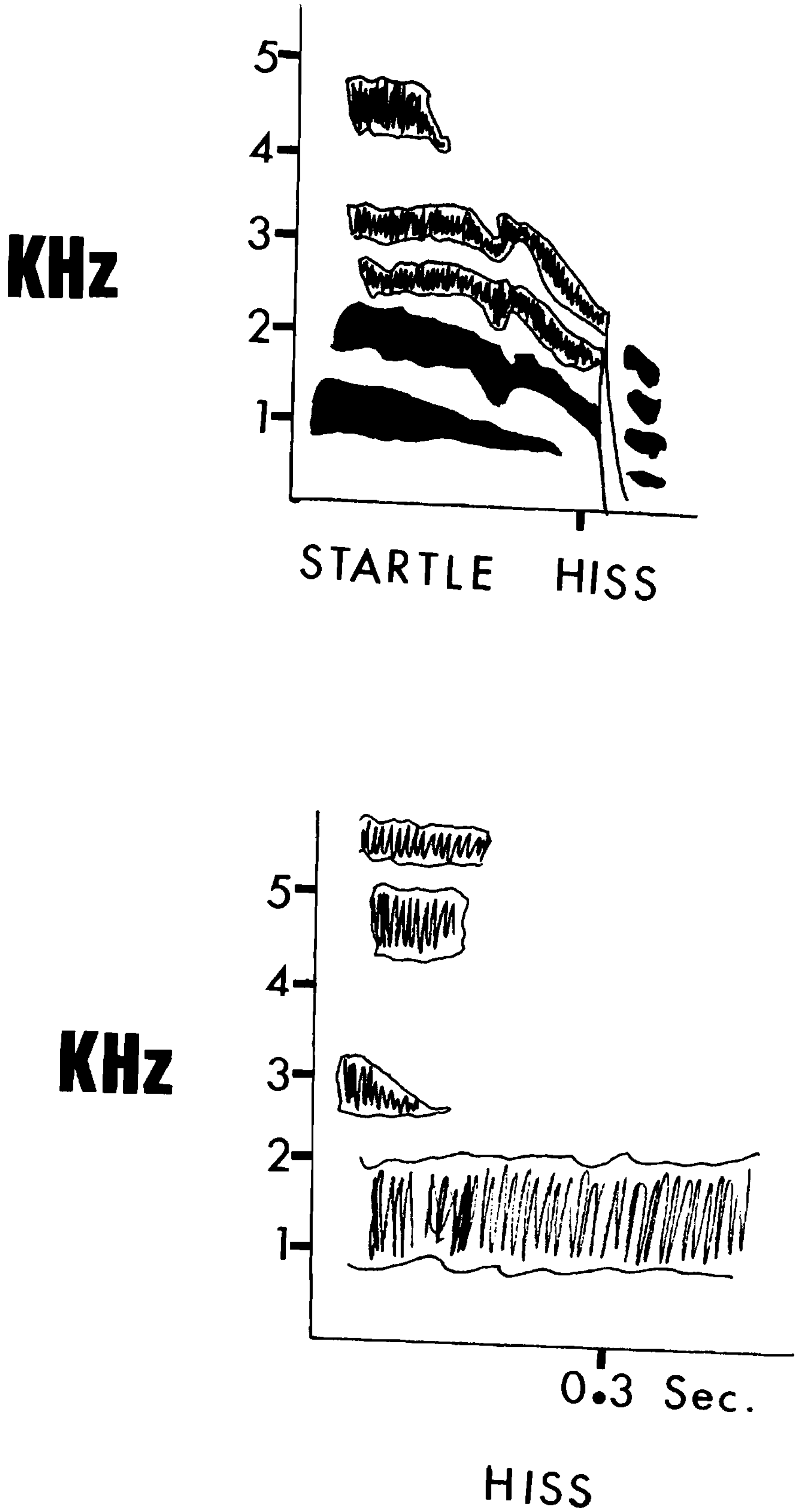

Figure 2. Sonographic Outline of the Two Most Frequent Vocalizations of the Desert Tortoise, the Hiss and the Startle Hiss.

The Utah Population - A Look in the 1970's

Ross Hardy

Since the publication of a ten year study (1936-46) of the desert tortoise by Woodbury and Hardy (1948), a few visits to the area of the marked reptiles have been made and records obtained showing the recovery of animals marked as much as 29 years, 5 months previously. Growth records for as much as 25 years, 10 months are given. Recommendations are listed for further studies and protection of the Utah tortoise population.

In August 1935, I went with a small group of students from the University of Utah on a field trip in ecology to various natural communities in southern Utah led by the late Dr. A. M. Woodbury. Among the places visited was the Beaverdam Slope of Washington County where a number of desert tortoises, *Gopherus agassizi*, were located. During the Thanksgiving vacation of 1936, Dr. Woodbury and a number of students again visited the area and scouted more widely, looking for reptile dens because Woodbury was then investigating the denning of rattlesnakes.

In the foothills of the Beaverdam Mountains, about a mile north of the Arizona state line in the southwestern part of Township 43S., R. 18W. east of a Dugway into one of the gravelly washes, twelve tortoises were found in dens (or tunnels) in the bank of the washes. These twelve were removed; marked, each a different way with red paint; and replaced in the den. Another trip was made to the area in November 1937 when eight more tortoises were marked.

In September 1938 I moved to St. George to teach at Dixie College and was invited to participate in the study. Being near, I was able to do most of the field work, but Woodbury and his students also worked during Thanksgiving and Easter vacations and occasionally in the summer. Because of the wear and tear on the painted surfaces, branding replaced the painting system. Eventually all of the painted tortoises were branded and others, to a total of 274, not counting a few captured animals, taken for laboratory study. During the first half of the study the animals were not measured so desirable data on growth is lacking in many cases. A note on some early results was published (Woodbury and Hardy, 1940). These investigations were continued until late spring 1946 when I left St. George for a position at Weber College in Ogden, Utah. Since both of us were at too great a distance to efficiently carry on the work, the results of ten years were published (Woodbury and Hardy, 1948).

In retrospect, one can see the many deficiencies and what should have been done but it must be remembered that this was undertaken while I had a full teaching load and was working on my own time on research for a doctoral dissertation and in those days there were few or no monetary grants for scientific research. During the school year 1941-42 while I was on leave at the University of Michigan, my place was taken by Dr. Frank Gould, botanist, and he kindly helped collect some data. Upon my return, from 1942 until 1945, the study was handicapped because of the wartime gasoline rationing and the small amount of my personal allotment was not sufficient to allow me to visit the area very often.

In 1949, I moved to Long Beach, California to help start what is now Californis State University, Long Beach. A number of times since then my son, Dr. Alan R. Hardy, and I have been able to visit the area. Part of the information so obtained has been published (Hardy, 1962 and Hardy, 1972). A summary of some of the more interesting records listed in these publications, plus others, may be of interest here.

Visits to the area made April 16, 1962, April 7, 1963, April 29, 1966 and November 26, 1969 resulted in the capture of 21 tortoises of which 10 had previously been marked. Eight of the 11 unmarked animals were branded and released and the three small ones were taken home for growth studies. The ten were all rebranded before being released since some of the original brands were becoming dim. Another tortoise retreated deeper into Cactus Den and could not be removed in the time available.

Of these tortoises, six were males, twelve were females and four unknown since they were too young for accurate determination. In our original study, a few that were thought to be females were later identified as males since the secondary sex characters may not always be evident but may come late in some animals.

Table 1 Some Growth Rates of Tortoises

	Time Interval		Growth in Length	
Bm♂	10/28/45-4/16/62	(16yrs. 5½mos.)	12mm.	(245mm.-257mm.)
Be♂	3/ 4/44-4/29/66	(22yrs. 2mos.)	6mm.	(265mm.-271mm.)
Ca♂	1/28/45-11/26/69	(24yrs. 10mos.)	10mm.	(257mm.-267mm.)
li♂	3/19/43-11/26/69	(26yrs. 8mos.)	3mm.	(260mm.-263mm.)
Bd♀	2/20/44-4/29/66	(22yrs. 2mos.)	8mm.	(251mm.-259mm.)
Bj♀	1/22/44-11/26/69	(25yrs. 10mos.)	1mm.	(217mm.-218mm.)

Elapsed Time Since First Marking

Bm♂	7/15/39 to 4/16/62	22 years and 9 months
Be♂	11/ 5/38 to 4/29/66	27 years and 6 months
Ca♂	8/ 3/39 to 11/26/69	30 years and 4 months
li♂	5/ 6/39 to 11/26/69	30 years and 7 months
Bd♀	11/28/36 to 4/29/66	29 years and 5 months
Bj♀	7/14/39 to 11/26/69	30 years and 4½ months
2a♀	6/16/39 to 4/ 7/63	23 years and 8½ months

(Bj♀ showed signs of senility with the dorsal scutes showing central concavities).

A new study and evaluation of the tortoises in this area is badly needed. What is the present population and how does it compare with that of 1936-46? Using the Lincoln-Peterson index, the population for the winter and early spring of 1945-46 showed 77 marked tortoises recaptured, 19 previously unmarked animals branded for the first time, out of a total of 274 tortoises marked in the area, giving a theoretical population of 318 in the area of a little over 1200 acres, or a theoretical area of 3.6 acres for each tortoise, or 177 tortoises per square mile in this most densely populated area.

One is tempted to use the figure given above of ten marked tortoises and eleven unmarked for the period 1962-69 but the number is too small to have any validity. What is sorely needed for the 1970's is a complete survey of ALL the dens and their inhabitants during the early October to early April period in the same winter, for only then can an estimate of the population be made. One thing we did learn is that the tortoises are too hard to find in the spring and summer months since they move around too much to be found with the necessary frequency.

My judgement, and it must be admitted as being very subjective, is that the population is greatly depleted since the days of our study. Without doubt, part of this is caused by the deterioration of the range because of overgrazing by livestock. Once fairly common grasses are no longer in evidence and the size and vigor of most shrubs has diminished. In 1941, a census (kind, height and width) of perennial shrubs was made on a quadrat just east of Dugway Den in the tortoise area. This was published as "quadrat #9" in a study of soils, plants and rodents (Hardy, 1945).

Another thing that should be done in the 1970's, in addition to the lessening of food composition by livestock, is to lessen the habitat interference by man. Damaging of dens through extensive digging is one of the worst kinds of vandalism. The burning of woodrat litter from dens in the mistaken belief of helping the tortoises entrance and exit does more damage than help because it allows more circulation of cold air in the den in winter. Many tortoises were observed "buried" in woodrat litter but they managed to get out the next spring. The few that were found dead in dens could have died from any one of many other causes as the great majority were in areas not plagued with woodrat litter. Also, the woodrat litter could possibly be a help in protecting tortoises from predators.

Any future study should be done with a permanent marking method. The brands we used have been deciphered over thirty years later. Coombs (undated M.S.) has marked many tortoises in the area with a small notch on selected marginal scutes. These are barely legible when new and can be easily damaged by gnawing predators or by accidental chipping over a number of years. The regeneration of horn and sloughing of bone in the brands of those marked by us were nearly repaired in spite of the large size of the mark. Any study or disturbance of the Woodbury and Hardy population, at least, should leave the animals marked so that future workers could keep track of individual tortoises designated in previous publications.

In summary, what is needed now is (1) that the tortoises be protected from so much competition for food, (2) intensive study and winter census of the population with minimum disturbance of the animals and their habitat, and (3) a permanent and universally understood system of marking to allow future studies, as needed, independent of any one person.

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Respiratory Disease in Captive Tortoises

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A current project supported by the Bureau of Land Management involves the study of approximately 35 tortoises, both normal and diseased, with objectives to:

1. Develop techniques for the positive identification of respiratory infection in tortoises, particularly those showing only subtle signs;

2. Identify the organism; and

3. Make recommendations for prevention or treatment of the disease.

The group includes animals varying in size from last year's hatchings to some with carapace lengths of 12 inches. The primary thrust of the study has been to establish a base line of the types of bacteria normally found in the respiratory passageways of healthy tortoises and to compare these with organisms found in diseased specimens.

Successive radiographic studies of the lungs have been made to establish norms in the hope that subtle changes in the lungs can be detected before outward signs are noted. This line of investigation shows some promise.

To summarize preliminary findings to date:

1. Many different types of bacteria are present in the mouth and upper airways of a "normal" tortoise. These are similar to, but not necessarily identical with, some species found in mammals.

2. Lung washings of normal animals, taken under sterile conditions, are devoid of bacteria.

3. The lungs of tortoises suffering from respiratory infections harbor opportunistic bacteria known to cause infections in many species of

animals. No single specific pathogen has been identified thus far. Some infectious bacteria have been cultured from many body organs as well as the lungs.

4. Tortoises with nasal discharges do not necessarily have pneumonia.

5. Nasal and oral discharges may originate in:

   a. Nasal cavity

   b. Oral cavity

   c. Trachea

   d. Lungs

   Any irritation of the mucous membranes may cause the flow of fluids and exudates and is not necessarily infectious.

6. The cause of death or tortoises exhibiting signs of respiratory infection may not be related to a true infection. This point will be discussed in more detail later.

7. The lungs of a tortoise are composed of a complicated series of sacs, communicating through narrow openings. Once infection settles in the lungs, it is extremely difficult to clear the infection and establish drainage of the debris. Any successes in treating respiratory infections thus far seem to involve those tortoises with upper airway involvement only.

8. I have postulated a theory that respiratory disease in tortoise is not a contagious disease, but results from decreased resistance which allows common, ubiquitous opportunistic bacteria to gain a foothold. A tortoise with signs of respiratory infection may die from bacterial infection, but death may be caused, instead, from the accumulated insults we call "stress".

A tortoise is a beautiful example of evolutionary adaptation. Since Triassic times, populations of animals have adapted to a particular habitat. The specific adaptive response varies with the species, but the operative mechanism is the same for all animals.

For example, the animal receives a stimulus, such as cold or heat, and successful individuals change their behavior accordingly. Response to stimulation may occur daily or it may occur seasonally.

If an animal is prevented from responding, the continued stimulation causes certain body changes which are collectively called stress. At first, these changes are adaptive, such as trying to mobilize energy stores to provide increased heat in response to cold.

The adrenal gland is stimulated and secretes steroid hormones to help the body cope with the stressful situation. Again, if the stimulus is temporary, no harm is done and the event would be considered a normal episode in the life of the animal. Continued and multiple stressor stimulation causes excessive production of adrenal hormones. The consequences in mammals are well known. We have no reason to believe that tortoises would not be affected to the same degree. In mammals, continuous stress produces:

1. Changes in blood cell counts which decrease the ability to combat infection;

2. Interference with immune responses, preventing the development of resistance to disease;

3. Poor wound healing; and

4. Behavioral changes

    a. Refusal of food

    b. Failure to exhibit normal reproductive responses

    c. Increased aggression

Any or all of these changes might affect the development of disease in a tortoise.

Some stressors for tortoises are:

1. Temperature extremes

2. Improper humidity (too high? too low?)

3. Inability to burrow (in the captive state)

4. Photoperiod differences (being kept in a pen with light on all the time)

5. Malnutrition

    a. Energy

    b. Vitamin A

    c. Protein

    d. Ca and P

While constant stressor stimulation causes increased production of adrenal hormones, if stimulation continues indefinately the adrenal gland may fail and production ceases. The animal becomes unable to cope with even the slightest stressful incident and dies from adrenal insufficiency.

We do not have any data on normal hormone levels, adrenal weights, or even microscopic examinations of the adrenal glands of tortoises, but the picture is clear and plausible.

Some captive tortoises are being given outstanding care. Members of the turtle and tortoise societies have intensively studied the biology of their pets and have made some progress in husbandry and particularly in regard to nutrition.

Nutritional status has a marked bearing on stress. Data comparing diets of wild and captive tortoises show that captive tortoises may be fed diets too low in certain essential nutrients. Table 1 shows the nutrient composition of various feeds taken from standard references.

a. Artificial feeds commonly fed to captive tortoises;

b. Native feeds on ranges inhabited by tortoises;

c. Artificial forages.

Note particularly the relative levels of protein, Vitamin A and energy contained in various feeds.

No matter how the data is calculated, the wild grasses, forbs and browse consumed by tortoises in the wild are more nutritious than the vegetables and fruits fed to captive animals. Compare protein levels, compare available energy, especially in regard to lettuce.

Many captive tortoises receive inadequate diets. Some pet owners say, "But we give our tortoise a variety of vegetables and it will balance its own diet". In some cases this is true, but I know from personal experience and observation that captive species given a choice frequently make the wrong choice and become imprinted on certain foods, frequently to their demise. Evolutionary laws compel successful wild populations to make correct choices over a long period of time, but this is not true of the captive individual.

A protein intake of 1-2 percent is incapable of sustaining normal life for prolonged periods. The animal with an intake that low can't combat infection.

To summarize, desert tortoises must be reared and husbanded in a manner to approximate a normal environment as closely as possible. A tortoise under too long and too severe stress may succumb to respiratory infection, but it is more apt to die of stress complications.

Do not assume that a captive-hatched-and-reared individual has satisfactorily adapted to a new environment. Adaptation is an evolutionary process requiring centuries, not months, to accomplish.

The treatment and rehabilitation of ailing tortoises is difficult. Others have described regimens. Adrenal steroid hormones are frequently used in treatment. As previously stated, a stressed animal may have an excessive production of adrenal hormones. Adding more as therapy would compound the damage.

Antibiotics are life saving when used judiciously. However, they may be toxic, or destroy the normal bacteria in the mouth and upper airways. If normal bacteria are destroyed, the way is clear for fungi or harmful bacteria to take over.

Blood levels of antibiotics must be maintained at a certain level to effectively combat infection. Levels of antibiotic in the blood of reptiles remain high for a lengthy period of time. No one knows how long effective levels persist in tortoises, but in snakes the levels from one injection can last three days. Giving antibiotics to tortoises every day may destroy the kidneys.

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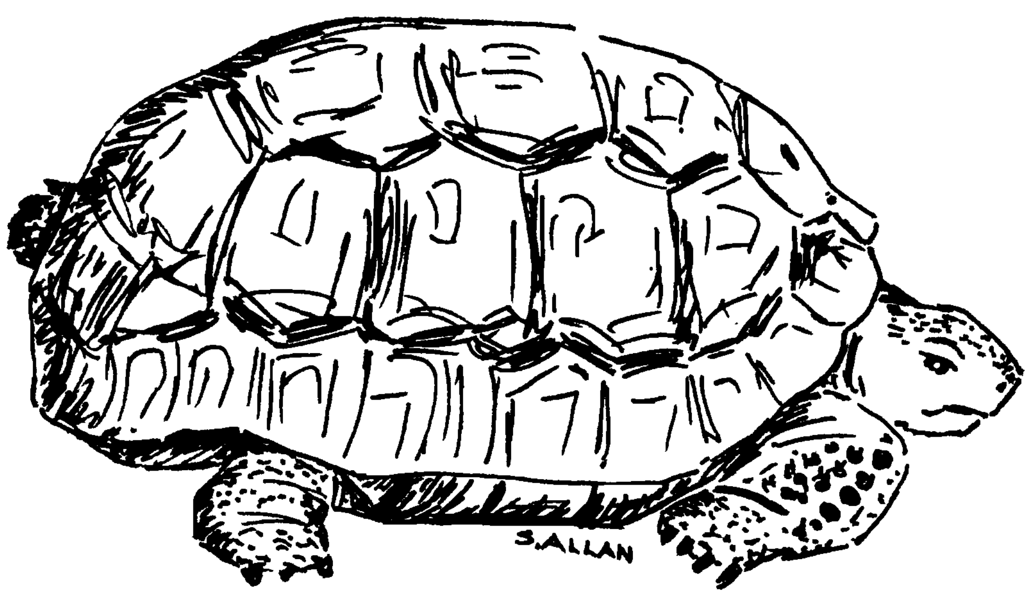

Diet Calculations for Tortoise

Testudo BMR = .360 KCals/Kg/hr.

3 Kg tortoise

3 Kg x .360 KCals/Kg/hr. x 24 hrs. = 25.92 KCals/24 hrs. basal

maintenance = 2 x basal = 51.84

consider 1/3 cardapace + plastron

3 Kg tortoise requires 34.56 KCals/day

2 Kg x 3% B.W. (Herbivore) should eat 60 gms/day

To get 34.00 KCal, the tortoise would have to consume 200 gms of lettuce per day or 10% of its body weight.

If eating Muhly grass, would only have to consume 5.7 gms. dry matter or .285% of body weight.

Table 1. Nutrient composition of various feeds.

	% Moisture	% Protein	% CHO	% Fat	% Crude Fiber	% Ca	% P	Vitamin A
Barley grain	11.00	11.60	68.20	1.90	5.00	.080	.720	
Barley grain	-0-	13.00	76.60	2.10	5.60	.090	.470	
7 day hydroponic barley	87.54	2.28	6.67	0.53	2.14	.031	.070	1,149.00
7 day hydroponic barley	-0-	18.31	53.34	4.24	17.17	.250	.550	10,000.00 IU/#
Friskies Puppy Food - Dried	12.00	27.00		10.00	5.00			
Friskies Canned Meat	76.00	9.00		3.50	1.50			
Purina Dog Chow Dried	12.00	21.00		8.00	4.50			
Cal Kan - Canned	78.00	10.00		6.00	1.50			
Alpo Canned Meat	75.00	12.00		9.00	1.50	.300	.220	

Table 1 Continued

NATIVE FOODS	% Moisture	% Protein	% CHO	% Fat	Crude Fiber	% Calcium	% Phosphorus	Vitamin A Iu/gm	Energy Kcals/gm
Browse - Winter (average)		6.83-7.18	30.14-36.14	5.23-7.71	31.7-34.5	1.78-2.10	.088-.095		5.20
Cactus *(opuntia spp.)*	79.4	1.0	12.1	.5	2.8	1.89	.02	1.9	.75
Forbs		9.36	38.8	2.96		1.79	.35		
Grasses - Winter (average)		3.10-4.29	35.8-40.4	.76-1.79	35.8-40.4	.51-1.07	.053-.074		3.80
Grasses - Summer (average)		6.2	34.8	2.2		.35	.22		
Bush Muhley grass	6.7	5.1	42.3	1.6	27.9	.75	.36	84.2	1.96
ARTIFICIAL FORAGES									
Alfalfa - fresh - full bloom	75.3	4.4	9.8	.6	7.5	.38	.07	56.2	1.96
Alfalfa hay	9	15.5	37.1	1.7	28.0	1.29	.21	108.	3.94
Blue grass (lawn)	67.1	2.4	15.0	1.2	11.4	.10	.09	79.3	1.58
Clover ariel parts - fresh	81	3.5	8.1	.8	4.6	.29	.06	89.6	.57
Clover hay	15	11.8	36.3	1.9	28.8	1.08	.20	56.7	2.09
Oats - Fresh -ariel parts	79.1	2.2	9.8	.7	2.0	.18	.16	145.	1.16
Oat hay	9.3	7.7	45.7	1.9	27.9	.22	.20	79.3	2.40

Table 1 Continued (Substitute fortoise foods)

	% Moisture	% Protein	% CHO	% Fat	Crude Fiber	% Calcium	% Phosphorus	Vitamin A Iu/gm	Energy Kcals/gm
Blueberry	83.2	.4	6.0	.4					.43
Broccoli	89.1	3.6	5.9	.3	1.5	.103	.078	25.00	.32
Cabbage	92.4	1.3	5.4	.2	.8	.049	.029	1.30	.24
Cranberry	87.9	.4	5.1	.3					.25
Dandelion greens	85.6	2.7	9.2	.6	1.6	.187	.066	140.	.45
Green Snap Beans	90.1	1.9	7.1	.2	1.0	.062	.062		.32
Lettuce-iceberg	95.1	1.2	2.5	.2	.5	.035	.026	9.70	.14
Lettuce-endive	93.1	1.7	4.1	.1	.9	.081	.054		.20
Lettuce-Romane	94.0	1.3	3.5	.3	.7	.068	.025		.18
Mung bean sprouts	88.8	3.8	6.6	.2	.7	.019	.064	.20	.35
Mustard greens	89.5	3.0	5.6	.5	1.1	.183	.05		.31
Spinach	90.7	3.2	4.3	.3	.6	.093	.051	70.	.26
Squash, winter	94.0	1.4	12.4	.3	1.4	.022	.038	37.	.50
Tomatoes, stewed	92.4	1.3	5.5	.2	.6	.015	.032		.26
Turnip greens	90.3	3.0	5.0	.3	.8	.246	.058	76.	.28

Accelerated Growth Rate and Early Maturity in *Gopherus Agassizi*

Crawford G. Jackson, Jr., John A. Trotter,
Thomas H. Trotter and Mary W. Trotter

A group of sibling desert tortoises, *Gopherus agassizi*, were measured at hatchling and at intervals afterwards for 3 years. Extraordinary mean increases in carapace length of 176% (156.3%-226%), 43% (39%-48%), and 11% (10%-13%) were observed for the first 3 years of growth, respectively. Mean carapace lengths at the end of the 1st, 2nd, and 3rd years corresponded approximately with those of *G. agassizi* measured previously by other investigators after 11, 17, and 18 years of growth, posthatching. The weight and length relationship is described by a geometric type curve whose equation is: wt (grams) = 0.00049 X carapace length $^{2.795}$. All tortoises appear to be ♂♂ at or very near sexual maturity as judged by gular development, tail size, enlarged chin glands, and increasing aggressiveness. The phenomenal growth rate and early maturity is ascribed to (1) not entering dormancy during the first two winters, and (2) being provided with continuous high quality nutrition.

It is generally accepted by herpetologists that many turtle species (especially terrestrial forms) have relatively slow growth rates, often requiring a number of years to reach sexual maturity.

Recently, Patterson and Brattstrom (1972) published the most extensive long-term tortoise growth study. Their work furthered the observations begun by Miller (1932, 1955) on a group of captive *Gopherus agassizi* hatchlings, bringing the observed growth period up to 30 years. Other scattered, fragmentary observations on the growth of both captive and wild *G. agassizi* were summarized from the literature by Ernst and Barbour (1972). Additional accounts were compiled by Hardy (1972). The most recent growth study of free-living *G. agassizi* involved 22 individuals (estimated age range, 3.3-10.1 yr) during a 10-year period in southern Nevada by Medica et al. (1975). Their tortoises exhibited a mean annual plastral growth rage of 9.1 mm (= 11.9 mm carapacial growth) which was positively correlated with winter rainfall. Additionally, their individual growth records indicated that almost no growth occurred before mid-April or after the first week in July, thus confining the growth season to only about 11 weeks. The observed carapace growth rate of captives (in the 50-200 mm carapace length range) reported by Patterson and Brattstrom (1972) is comparable to that of the free-living tortoises studied by Medica et al. (1975), although the rate is slightly greater in the wild group. None of these previous accounts suggests the extraordinary growth potential which the desert tortoise possesses.

We report herein observations and measurements on four *G. agassizi* from hatching to three years of age under conditions of intensive care. We feel the observations are noteworthy because they demonstrate the genetic potential of the species to exhibit an exceedingly rapid growth rate under certain circumstances.

METHODS

Four hatchlings were obtained from a clutch of six eggs laid 23 July 1972. The female parent was obtained in 1961 at which time she was obviously sexually immature. The male parent, obtained in 1962, was also sexually immature. The two were confined together, but courtship behavior was not observed until 1970. The female's first clutch was a single egg (which failed to hatch) laid in 1971. Although the percentage of the hatchlings is definately known, we have no locality data on the parents, but suspect that they were collected in California. Hatchlings emerged during 8-11 November 1972 after incubation periods from 108-111 days. Three linear shell measurements were made commencing 18 November 1972: (1) carapace length -- greatest straight-line distance measured along the midline, (2) carapace width -- maximum straight-line width, and (3) shell thickness (= shell height or carapace height of other authors) -- greatest dorsoventral thickness measured on the midline. Weighing was not begun until the tortoises were six months old.

The tortoises were maintained in a private home (having central heating) in San Diego, California. The temperature control thermostat was set at 20°C from 0700 to 2300 h, and at 16°C from 2300 to 0700 h. The animals were kept in a cardboard box (76 cm X 56 cm X 23 cm) for the first 1½ years, then transferred to a wooden pen (137 cm X 76 cm X 23 cm) for the remainder of the study. A shallow wide dish supplied water *ad libitum*, and a 100-W incandescent light with reflector suspended about 30 cm above one corner of the pen floor furnished supplementary heat. A small "retreat" box was kept in the pen.

The yolk sacs were absorbed within two days post-hatching, and all hatchlings accepted food and water immediately. For the first few weeks, the tortoises were fed a finely chopped mixture of avocados, tomatoes and lettuce twice each day. Additionally, large pieces of lettuce were placed in the box several times during the day. Each afternoon the tortoises were removed to a lawn and allowed to graze for 1-2 hours on grass, clover, *Dichondra*, dandelion leaves and flowers. Depending upon availability, supplementary feedings of squash and hibiscus flowers were given. A commercial product, Litter-Green®, was used continuously as a thin substrate in the pen. It is composed entirely of ground, pelleted alfalfa and doubtless contributes to the nutrition since it is occasionally eaten directly. Also, it was frequently ingested secondarily with other food in the pen and as a contaminant in the drinking water.

Ten drops of a water-soluble, commercial multivitamin supplement (Avitron®) were added to the container of drinking water (for 1 day only) every other week. Each tortoise was also given a minute droplet of cod liver oil each month.

RESULTS

The exceptional growth rate is shown graphically in Figure 1. Astonishingly, the mean carapace length attained at 1 year of age corresponds approximately with the estimated mean carapace length of the Miller captives at 11 years of age. Grant (1936) estimated that about 5 years were required for *G. agassizi* to reach a carapace length of 100 mm. Two of our tortoises reached 100 mm at 6 months, and all exceeded it by 8 months of age. Perhaps more spectacular is the finding that mean carapace lengths at 2 and 3 years of age correspond approximately to the estimated mean carapace lengths of the Miller captives at 17 and 18 years of age, respectively. The 15-20 year time segment posthatching was considered the probable interval (in the life cycle) of sexual maturity in nature by Woodbury and Hardy (1948) and Miller (1955).

Table 1 presents detailed data and a statistical analysis of linear growth in our tortoises. Variability, as indicated by coefficients of variation (V) was greatest at hatching for carapace length and carapace width, but fluctuated irregularly for the three 1-year growth periods thereafter. For shell thickness, a different situation obtained, with variability progressively increasing to a final value nearly 2½ X that possessed by the hatchlings.

In all three shell parameters, mean percentage of increase substantially exceeded 100 percent for the first year of growth, then declined sharply and progressively for the 2nd and 3rd years, respectively. With regard to differential shell growth, rates of increase for the 1st and 2nd years are CL CW ST, but for the 3rd year they change to ST CL CW. However, it should be noted that the difference in growth rates for carapace length and carapace width had become nearly equal during the 3rd year. This indicates that the adult proportional relationship between these shell dimensions was being approached rapidly. At the end of three years posthatching, the proportional relationships between carapace length, carapace width and shell thickness were within the ranges for a large sample of wild males measured by Woodbury and Hardy (1948). However, the relatively slightly greater dorsoventral fullness of our tortoises caused the shell thickness/carapace length and the shell thickness/carapace width ratios to lie near the upper end of the ranges reported by those authors.

Extrapolation (from the data of Table 1) to the fourth growth period would yield an estimated mean annual percentage increase rate of 3 percent for carapace increment acquired between the 3rd and 4th years posthatching. At 3 percent per annum increase, one would predict a mean carapace length of 215 mm for our tortoises at the end of their 4th year, an arithmetic growth rate of only about 0.5 mm/month.

Table 2 contains detailed data and statistical analysis of weight increase. No hatchling weights were recorded. The only hatchling weight information of which we are aware is that of Grant (1936) who found a hatchling (carapace length = 44 mm) which weighed 19.7 g at 4 days posthatching. Variability at time of first weighing, and at the end of the 2nd and 3rd years of growth, was small, but was always greater than variability in linear shell measurements. Like rates of increase in shell dimensions, weight increment rates show a drastic downward trend for the two periods observed. The rate of decline is relatively greater than that of the shell dimensions which is expected since linear changes vary with the square, and weight changes with the cube. Figure 2 shows the rectilinear relationship between the logarithm of mean carapace length and the logarithm of mean weight for the captives at seven consecutive times.

Figure 3 shows the peculiar "knobby" condition characteristic of each tortoise. It appears that such extremely rapid growth produces a ramarkable accumulation of epidermal laminae on the carapace. Unless the association we observed is fortuitous, this prominent characteristic would appear useful to identify the more rapidly growing individuals in the natural population. However, Dr. Kristin Berry (*personal communication*) who has observed several hundred wild desert tortoises, has seen the knobby carapace condition only in individuals reared in captivity.

INDIVIDUAL VARIATION

Although overall growth was reasonably uniform, and mean values certainly high, the exceptional growth capacity of certain individuals is worthy of attention. Tortoise No. 3 (smallest hatchling) was fastest growing in carapace length, carapace width, and shell thickness, exhibiting approximate rates of increase of 226 percent, 193 percent, and 167 percent respectively during the 1st year. Tortoise No. 2 (largest hatchling) made the greatest relative increase in weight, by maintaining a weight gain rate of $\approx$ 200 percent during its 2nd year of growth.

Carapace length is the most frequently used standard of size in chelonians, and the following data are presented to illustrate intragroup differences (in rank order) of percentage increase for that dimension: 1972-1973__3 > 1 > 4 > 2; 1973-1974__2 > 1 > 4 > 3; 1974-1975__1 > 3 > 4 > 2. Only Tortoise No. 4 maintained the same rank order during the entire observation period.

SEASONAL VARIATION

Figure 4 shows size (carapace length) at various points in time during the period of our observations. A complex situation appears to be present. One expects the November 1974 to July 1975 period to produce less growth than the July 1975 to November 1975 period, due to dormancy (i.e., greatly reduced activity) and drastically reduced food intake which were characteristic of the former period. However, during the 1st year of life, the November to July period actually revealed the tortoises growing at a faster rate than in the July to November period immediately following. During the 2nd year of life, the growth curve slope for the November to July period (which corresponds to the "dormant" period of the 1st year) appears only slightly steeper than that of the immediately following July to November period (which corresponds to the "active" period of the 1st year). However, data are few and the apparent difference could well be spurious. In November 1974, the tortoises entered their first period of dormancy. During the 3rd year of life, a prominent difference occurs between the slope of the growth curve for the dormant (i.e., reduced activity) period (November 1974-July 1975) and that for the active period (July 1975-November 1975) which immediately followed it. Mean percentage increase in carapace length during the dormant period was 3.6 percent, versus 7.5 percent for the active period. The controlled temperature regime was the same during both periods. From the findings of Woodbury and Hardy (1948) and Brattstrom (1961) regarding burrow ambient air temperatures, and body temperatures, it appears that the year-round ambient air temperatures of the room wherein the tortoises resided were usually slightly higher than ambient burrow temperatures.

During the third winter (when first dormancy occurred) the tortoises were markedly inactive. However, Tortoises No. 1 and No. 2 emerged from the common retreat box at about 3-week intervals to drink (and sometimes eat small amounts of greens). Tortoise No. 3 did likewise at intervals of about a week, but No. 4 remained completely inactive until early July. Although three tortoises gradually increased their activity during June, none became fully active until July. Interestingly, final sizes (i.e., carapace lengths) correlate with the pattern of differential activity in that Tortoise No. 3 was largest, No. 4 smallest, and Nos. 1 and 2 intermediate in size.

DISCUSSION

Our data clearly demonstrate that some individuals of the desert tortoise possess the genetic potential to grow at an extraordinary rate which far exceeds both that observed in nature and rates previously reported for long-term captives.

Because the tortoises became dormant in November at the beginning of their 3rd year of life, despite the fact that the ambient indoor temperature regime was unaltered, an inherent dormancy cycle is suggested. Jackson (1970) found the growth rate of the aquatic turtle, *Chrysemys concinna suwanniensis*, to decline abruptly in November, and not rise again until the following spring, although abundant food was available and water temperatures remained almost constant throughout the year.

We suspect that the annual cycle of alternating activity-dormancy observed in nature for *Gopherus agassizi* is based on a biphasic annual metabolic cycle. If such is true, a possible explanation of our findings is that the tactile and other stimulation immediately following hatching, triggered the active metabolic phase causing growth to be rapid during fall and winter, then begin to decline in spring (Figure 4) around the time that Medica et al. (1975) observed growth to resume in wild individuals. In effect, the postulated active and inactive metabolic phases were reversed. During the 2nd year of life, biphasic differences seem greatly diminished or their oscillation dampened. At the beginning of the 3rd year of life (i.e., November 1974), the tortoises appear to have changed phase with the result that the biphasic sequence of the 3rd year is the reverse of that for the 1st year of life.

We attribute the exceptionally rapid growth rates to a highly stimulating environment and a very adequate dietary standard from hatching onward. The significance of our observations lies in demonstrating that growth and early maturity can be profoundly accelerated or forced in at least one species of true tortoises. Since the possibility of extinction in the foreseeable future exists for several species of tortoises, the potential for being reared and bred in captivity is of some concern to biologists.

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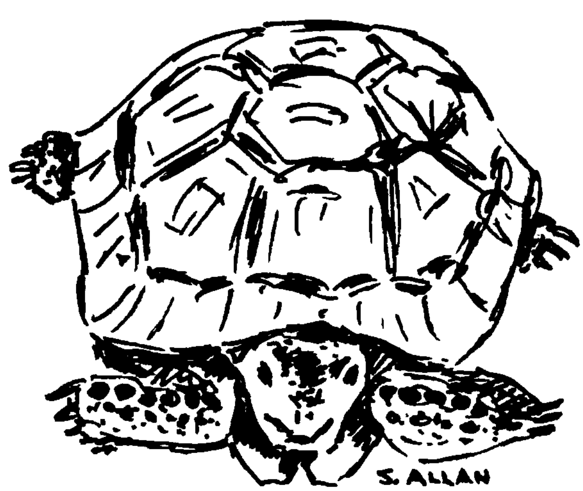


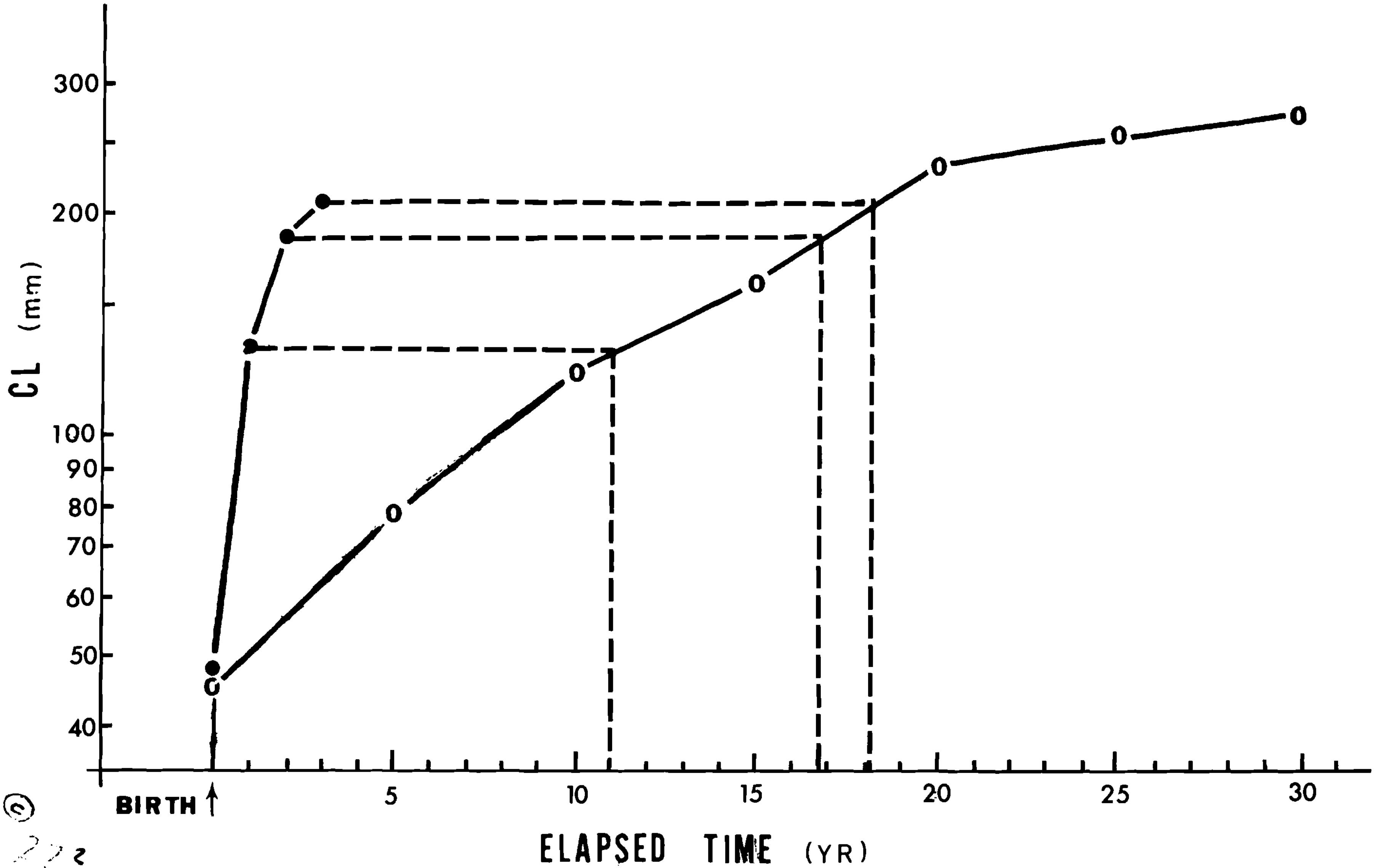


Figure 1. Comparison of carapace length (CL) growth curve of *Gopherus agassizi* of present study with that of Miller captives (data from Patterson and Brattstrom, 1972). Points represent mean values. Dashed lines are estimated age differences at equivalent sizes between the two groups. Closed circles (●) = present study; open circles (O) = Miller captives.

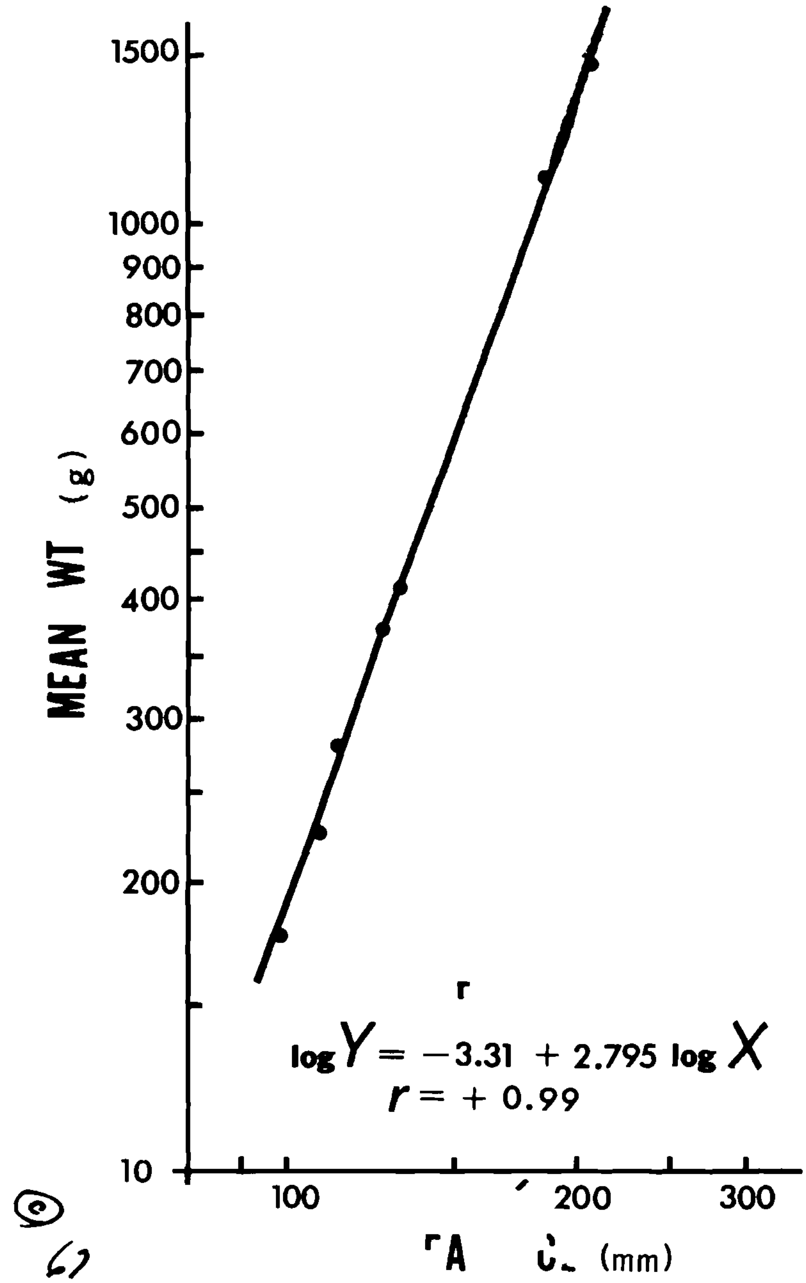


Figure 2. Relationship between mean weight (WT) and mean carapace length (CL) of captive *Gopherus agassizi* of this study. Each point is based on average for 4 individuals. Estimated mean weight = 0.00049 X $CL^{2.795}$.

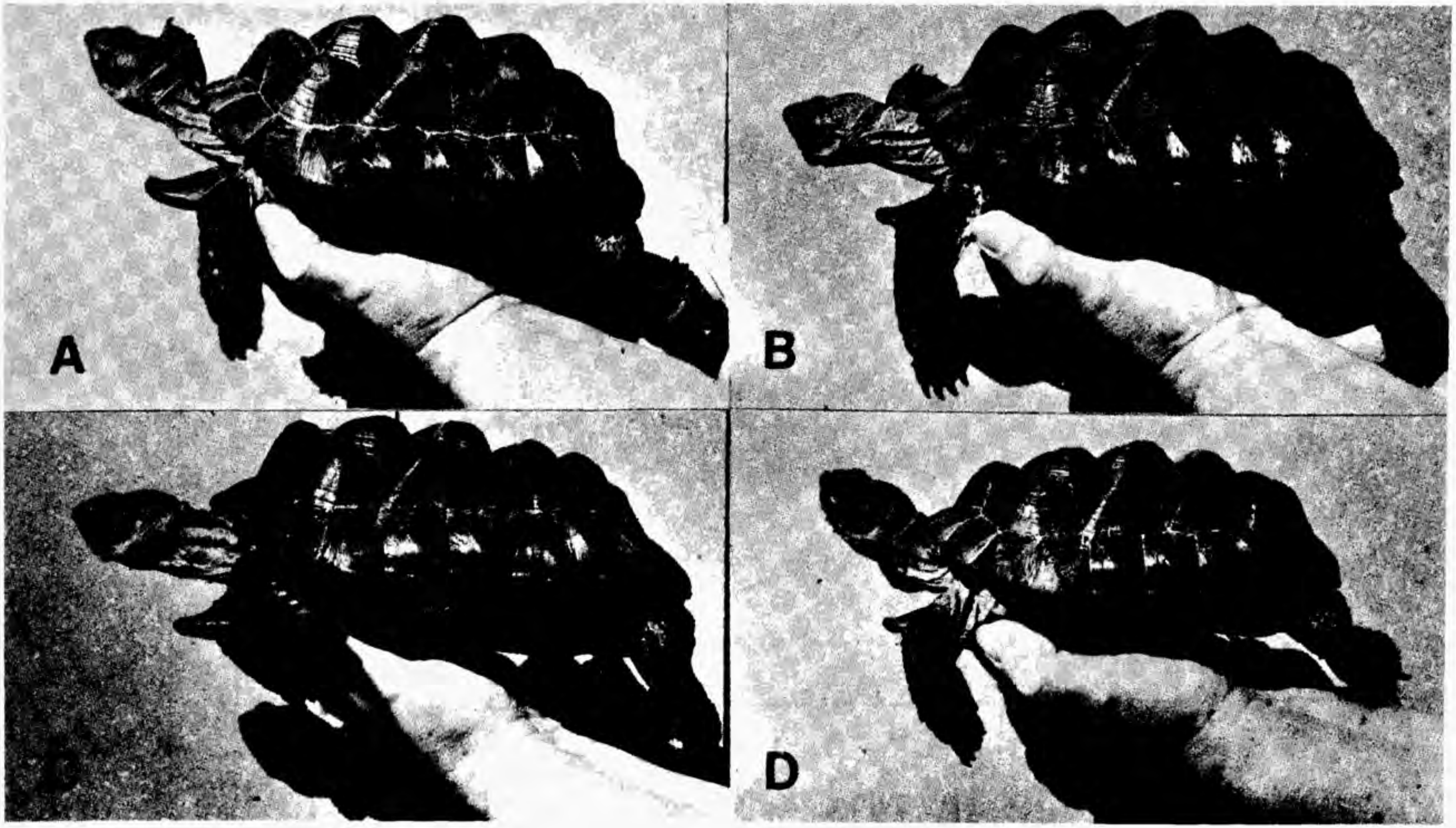


Figure 3. Lateral views of captive *Gopherus agassizi* of present study. A-D are tortoises No. 1 through 4, respectively. Note prominent gular projections in all individuals, and marked pyramidal shape of central (vertebral) and lateral (costal) scutes. Photographs taken September 1975.

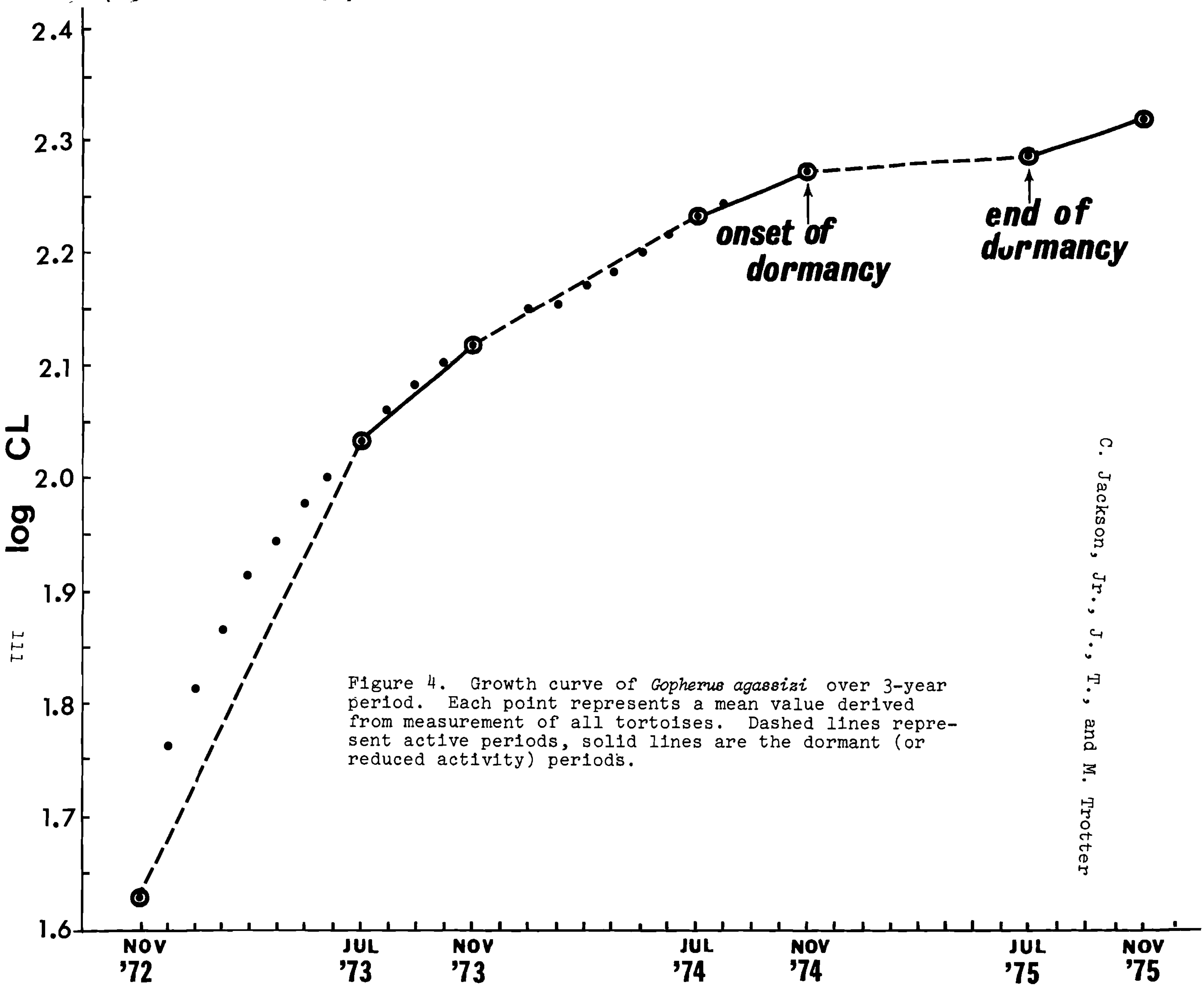


Figure 4. Growth curve of *Gopherus agassizi* over 3-year period. Each point represents a mean value derived from measurement of all tortoises. Dashed lines represent active periods, solid lines are the dormant (or reduced activity) periods.

Table 1. Growth in carapace length, carapace width, and shell thickness of *Gopherus agassizi*. Measurements are in millimeters.

	Size at hatching and at end of annual growth periods			Percentage increase	Absolute increment (mm/yr)
Period	Range	$\tilde{x} \pm$ SE	V (%)	$\tilde{x}$ (range)	$\tilde{x}$ (range)
			CARAPACE LENGTH		
HATCHING (Nov '72)	42.9 - 50.8	47.8 ± 1.78	7.4	. . .	. . .
Nov '72 - Nov '73	123.8 - 139.7	131.2 ± 3.26	5.0	176.0 (156.3 - 225.6)	83.4 (76.2 - 96.8)
Nov '73 - Nov '74	173.0 - 194.5	187.7 ± 4.98	5.3	43.1 (39.2 - 48.2)	56.5 (49.2 - 62.7)
Nov '74 - Nov '75	191.0 - 218.0	209.0 ± 6.12	5.9	11.3 (9.9 - 12.9)	21.3 (18.0 - 24.5)
			CARAPACE WIDTH		
HATCHING (Nov '72)	31.4 - 39.7	37.5 ± 1.24	6.5	. . .	. . .
Nov '72 - Nov '73	92.1 - 100.0	95.1 ± 1.72	3.6	154.8 (132.0 - 193.3)	57.6 (52.4 - 65.9)
Nov '73 - Nov '74	128.3 - 137.2	133.7 ± 2.16	3.2	40.7 (36.9 - 49.0)	38.6 (34.6 - 45.1)
Nov '74 - Nov '75	139.0 - 153.0	148.0 ± 3.32	4.5	10.6 (8.3 - 11.5)	14.1 (10.7 - 15.8)
			SHELL THICKNESS		
HATCHING (Nov '72)	23.8 - 25.4	24.9 ± 0.38	3.1	. . .	. . .
Nov '72 - Nov '73	57.2 - 63.5	59.9 ± 1.35	4.5	141.2 (125.2 - 166.8)	35.0 (31.8 - 39.7)
Nov '73 - Nov '74	74.6 - 85.7	80.9 ± 2.40	5.9	35.1 (27.1 - 40.2)	21.0 (15.9 - 23.0)
Nov '74 - Nov '75	84.0 - 100.0	94.2 ± 3.57	7.6	16.3 (12.6 - 18.4)	13.3 (9.4 - 14.8)

Table 2. Growth in weight of *Gopherus agassizi*. Weights are in grams.

Period	Size at end of each annual growing period			Percentage increase	Absolute increment (g/yr)
	Range	$\tilde{x} \pm$ SE	V (%)	$\tilde{x}$ (range)	$\tilde{x}$ (range)
November 1973	371-485	413 ± 25.3	12.2	. . .	. . .
Nov. '73-Nov. '74	968-1,243	1,128 ± 57.6	10.3	174.2 (156.3-200.3)	715 (597-775)
Nov. '74-Nov. '75	1,156-1,580	1,452 ± 99.4	13.7	28.4 (19.4-33.9)	324 (188-387)

Southern California Edison and the Desert Tortoise: A Review of Impacts and Mitigation

David W. Stevens

INTRODUCTION

Southern California Edison Company is one of the largest utilities in the United States. It serves electric power to approximately 7.2 million people in Southern California. Edison's service territory is approximately 50,000 square miles. The figure that follows shows the approximate territory.

The areas of greatest demand within Edison's service territory are Los Angeles and Orange Counties. Historically, the major bulk of the electricity required to meet Edison's demand was generated near the demand centers by gas and oil burning generating plants. The major exception to this was the hydro generating facilities in California's Sierra Nevada and Hoover Dam bordering Nevada and Arizona. Edison's first nuclear generating station, the San Onofre plant, was also located near the demand center of Orange County. Most of these steam electric generating facilities have been located along the coast in order to use ocean water for condenser cooling.

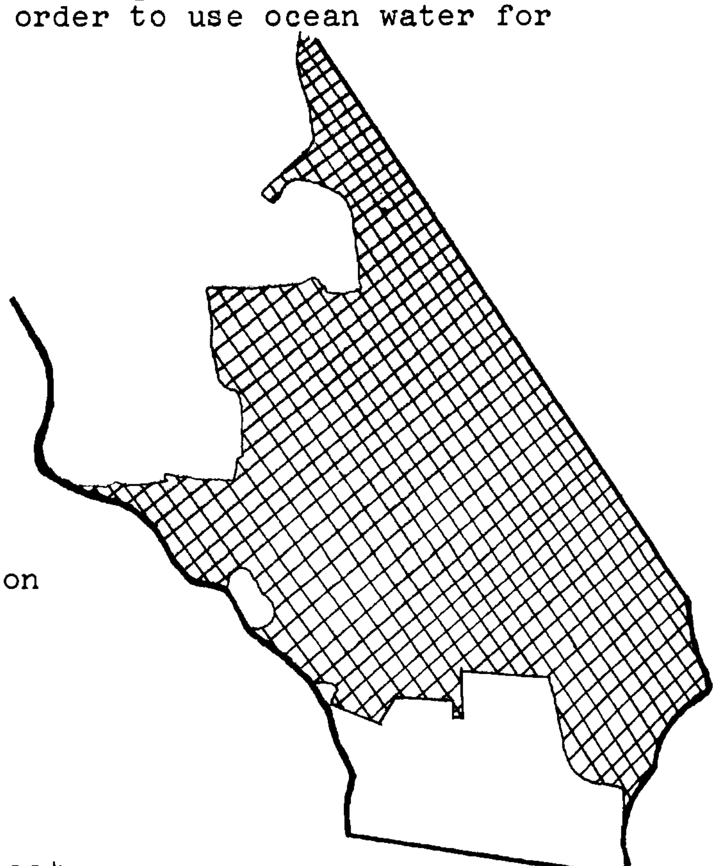


Figure 1.
Service territory of
Southern California Edison
Company

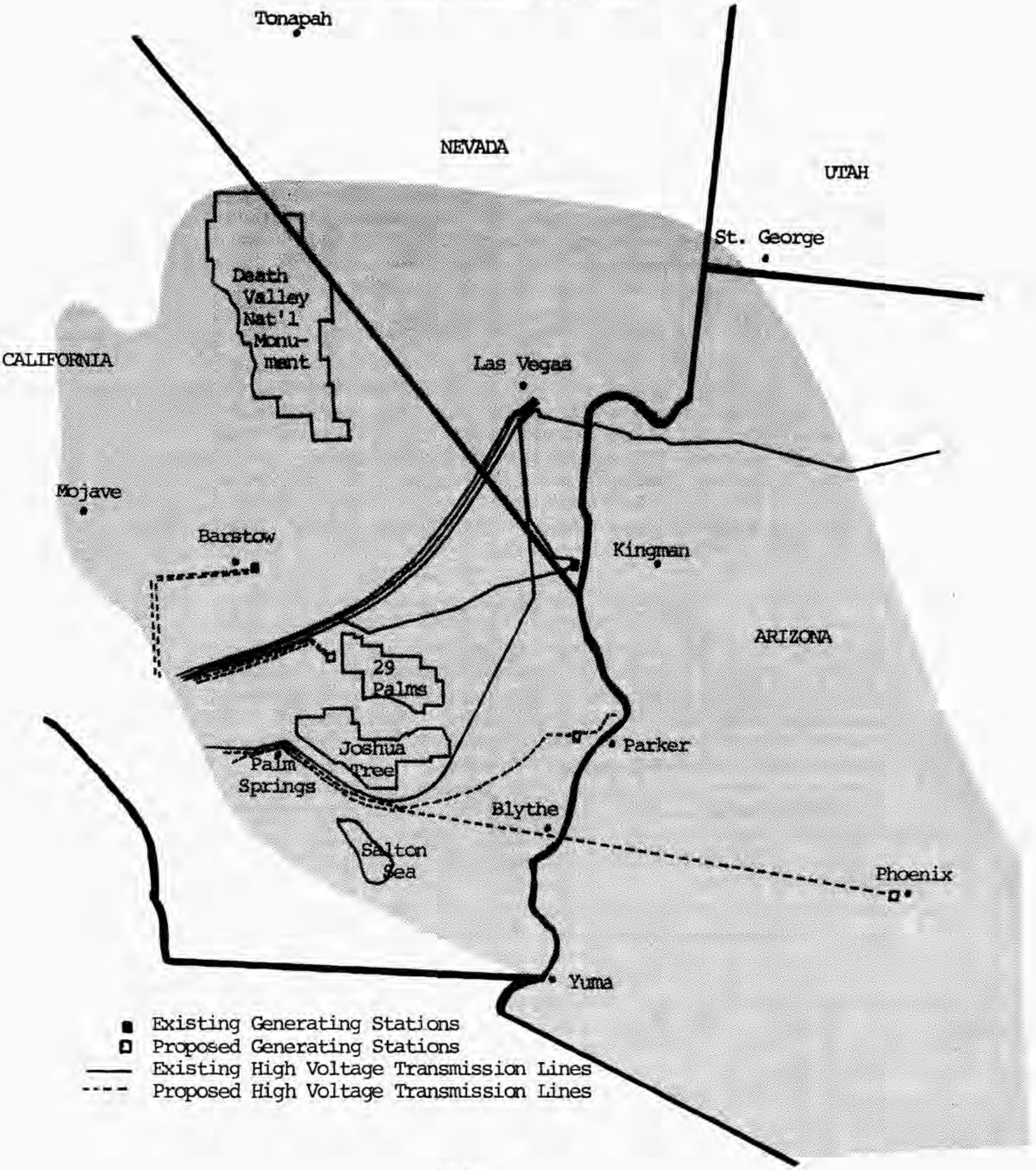
With the establishment of the Coastal Commission in California in 1974, and the evolving clean air standards for the south coast air basin, there is increasing pressure for Edison to locate future generating facilities away from the coast and, consequently, away from the major demand areas. As one moves away from the demand centers, other means of generating become economically viable, i.e. coal-fired generating plants. For Edison to move inland away from the coast and away from the south coast air basin is to move into and across the southwestern deserts -- into and across desert tortoise habitat. Thus, impact to the desert tortoise will inevitably occur as a result of the construction of generating facilities and the associated transmission lines required to transport the electricity to the demand areas. Figure 2 shows the major existing and proposed Edison facilities that may impact the desert tortoise and its habitat. These facilities include all known generating plants and high voltage 220 kV and 500 kV transmission lines. Those facilities indicated as proposed include all major facilities planned by Edison for the eastern desert area for the next 15 years. Other alternative sources such as solar, geothermal, wind and combined cycle are being studied but no specific plants or sites are being studied at this time.

PAST AND PRESENT IMPACTS

Existing major Edison facilities located within the known desert tortoise distribution have resulted in approximately 980 miles of high voltage transmission lines and two generating stations. In addition, two generating stations and about 1000 miles of high voltage transmission line are planned.

Requirements for transmission lines include access roads that generally range between 14 and 18 feet in width. On level terrain, access road lengths approximately equal the length of the line. In more hilly terrain the length of the access road is increased due to engineering requirements. As a general rule, access roads are approximately 1.5 times the length of the transmission lines. For passage of major transmission line construction equipment, roads are generally designed to have a grade not greater than approximately 18 percent. Additionally, the area around transmission towers becomes temporarily impacted due to construction activities, but the vegetation in desert areas is not purposely removed, i.e. blading of a tower pad by a caterpillar is not normally done.

FIGURE 2
EXISTING AND PROPOSED EDISON FACILITIES
WITHIN DESERT TORTOISE HABITAT



Generating plant facilities occupy areas of land appropriate to accommodate the plant and appurtenant facilities such as the switch rack, cooling towers, cooling ponds, maintenance facilities, office buildings, parking lots, etc. The required area depends upon the size and type of generating facility planned. A combined cycle gas or oil fired station may require approximately one square mile, a nuclear plant one to one and one half square miles and a coal fired plant about two to three square miles.

In studying the impact to desert tortoises by two Southern California Edison transmission lines, Luckenbach (1975) states that these facilities impact the tortoise in two ways: 1) loss of habitat and 2) increased road access that results in increased tortoise collecting pressure. Stevens (1974) includes a third impact - heavy use of some access roads by off-road vehicles. The latter impact increases access road width, impacts habitat quantity and quality (Marlow, 1974) and destroys animals due to direct collision (Marlow, 1974; Luckenbach, 1975).

Luckenbach (1975) estimates that in 75 miles of transmission access road surveyed, 9.6 square miles of the area were lost. Loss around towers (306 structures) was an additional 4.4 square miles. Luckenbach estimates that tortoises occurred along approximately 33 percent of the lines surveyed. Therefore, a total of about 4.6 square miles of tortoise habitat was lost while the net habitat loss was 9.95 square miles.

In his surveys, Luckenbach found the access road to average about 30 feet in width - nearly double that generally stipulated by Edison construction plans. Heavy visitor use of these roads was cited. However, Southern California Edison maintenance crews probably do not use the roads more than three to four times per year. Thus, it is concluded that secondary users of access roads may contribute approximately half of the habitat loss attributed to access roads by Luckehbach. Attempts by Edison to prevent the secondary use of access roads has, for the most part, proven ineffective.

There may be limited beneficial effects from access roads - berms resulting from the overcasting of soils due to road construction. Because this overcast soil is friable, tortoises frequently build burrows in the berms (Luckenbach, 1975). Further, as Luckenbach suggests, due to the edaphic nature of berms, vegetative growth may be greater than occurs in adjacent, undisturbed areas. This fact has also been documented by Johnson, Vasek and Yonkers (1975). Vasek, Johnson and Brum (1975) have presented data indicating an increase in vegetative cover directly beneath transmission line conductors as opposed to control areas. The potential benefit of this increased cover to tortoises has not been studied, however.

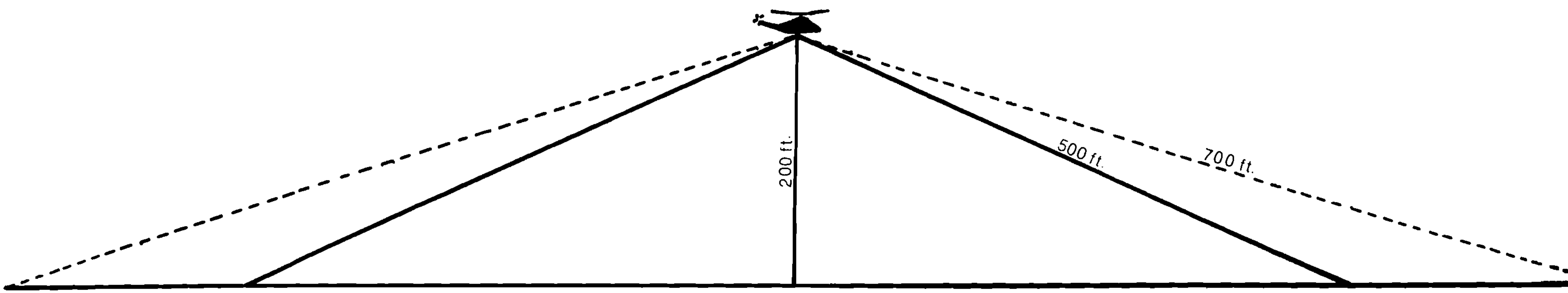
MINIMIZATION OF POTENTIAL IMPACT

In his 1975 paper, Luckehbach suggests that, "In light of current tortoise distributional data, efforts should be made to locate transmission line routes which, as well as possible, avoid areas of high tortoise densities".

There are three levels of effort Edison employs in studying alternative and preferred transmission line routes for the presence and general density of tortoises. These include: 1) helicopter aerial transect analysis during early project planning, 2) study leading to the preparation of the project environmental report, and 3) inspection of individual tower sites and access roads with project engineers to determine if any tortoise burrows will be impacted. In this latter case, spur roads or individual tower sites, realignment of roads or movement of tower locations are recommended to the project engineers. In most cases these recommendations can be implemented. In situations where the recommended move causes an engineering problem, a compromise can be accomplished. This compromise includes the commitment by Edison to excavate pallets and burrows for obtainable ecological data and the removal and relocation of tortoises that may be impacted to any construction activities.

It is during early project planning when alternate sites are under evaluation that relative tortoise densities are determined. A site or route is recommended to project engineers that will least impact tortoises. The aerial surveys to determine relative tortoise densities are conducted by helicopter. Two persons well trained in tortoise burrow and pallet recognition are utilized. The helicopter is flown at an above ground elevation of approximately 200 feet and at air speeds varying from 70 to 90 miles per hour.

DESERT TORTOISE AERIAL TRANSECT



200 x 500 (0.17 MI.) TRANSECT

50 MPH = 10.4 mi^2

70 MPH = 12.1 $mi.^2$

90 MPH = 15.6 $mi.^2$

200 x 700 (0.25 MI.) TRANSECT

50 MPH = 12.5 mi^2

70 MPH = 17.5 $mi.^2$

90 MPH = 22.5 $mi.^2$

A competent observer on each side of the helicopter observing burrows at an air to ground diagonal of 500 feet can effectively survey a transect 0.17 miles wide. At 70 miles per hour approximately 12 square miles per hour are surveyed. It is estimated that a burrow recognition realiability of approximately 80 percent is realized. As Figure 3 indicates, greater ground coverage per hour can be realized at greater lateral distances and at greater speeds. However, the efficiency of burrow recognition is reduced. This survey technique has proven an extraordinarily effective survey method. It has proven most effective in the tortoise habitats of California, Nevada and Utah.

Surveys conducted in the Sonoran Desert of Arizona during the summer of 1975 indicate that the density of badgers, *Taxidea taxus*, is much higher in the region than in other desert areas surveyed. Badger burrows are not as readily differentiated from tortoise burrows during the aerial transect due to similar size and shape. Frequent ground stops were needed in the Sonoran Desert to differentiate badger burrows from tortoise burrows. This reduced the effectiveness of this survey method in Arizona and increased its cost.

Comparison of general habitat and composition and the degree of existing impact and surface evidence of other faunal activity can generally be assessed over a large area utilizing a helicopter. Average present day cost estimates for helicopters suitable for this work is approximately $150.00 per hour. This estimate is for such helicopters as the three place Bell G3-B and Hiller 12E. These helicopters have cruising speeds of 80 to 85 miles per hour. Thus, depending upon the degree of accuracy of data acquisition desired, 10.5 to 22.5 square miles per hour of habitat and tortoise presence can be achieved. Comparing conventional cursory ground survey methods with the helicopter aerial survey method, inherent values, both economic and biological, are readily demonstrable. The helicopter as a tool for resource inventory is invaluable. The cost effectiveness of its use by resource agencies concerned with ecological problems should be fully explored.

SUMMARY

In the past three to four years Southern California Edison Company has become aware of the need and requirement for the protection of the desert tortoise.

Significant steps in reducing impact to *Gopherus* have been developed and implemented; these include helicopter survey analysis during early project planning and inspection of all access roads and facility sites for tortoise burrows. These methods have significantly reduced potential tortoise and tortoise habitat impact for projects planned and studied in the past three years. Continual study and evaluation of Edison siting procedures by its biological staff should continue to improve methods for reducing tortoise impact.

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The Utah Population of the Desert Tortoise, *Gopherus agassizi*, is Endangered!

Glenn R. Stewart

The desert tortoise in Utah is restricted to about fifty square miles of desert habitat between Beaver Dam Wash and the Beaver Dam Mountains in the extreme southwestern corner of the State (Washington County). Although not taxonomically distinct, the Beaver Dam population occurs at the extreme northeastern edge of the species' range. Between 1936 and 1946 this population was the subject of an intensive study by Angus M. Woodbury and Ross Hardy. Prior to the disturbances of civilization, the population may have contained about 2,000 tortoises.

Recent studies by Eric M. Coombs indicate that less than 300 tortoises remain. The population now is composed primarily of old individuals, with males outnumbering females by approximately 2:1. Little recruitment of young is occurring. Overcollecting of tortoises, especially females, and overgrazing by livestock appear to be the principal factors which have caused the population's decline.

While State law currently prohibits the taking and possession of desert tortoises, recovery of the Beaver Dam population can not be expected unless the habitat is given complete protection from grazing and other disturbances. Designation of the tortoise habitat as a Class IV Natural Area (U.S. Bureau of Land Management) should provide this protection. However, effective management of the Beaver Dam population may require that it be officially recognized as an endangered population under the authority of the Endangered Species Act of 1973.

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Desert Tortoise Preserve Committee Report

Elizabeth W. Forgey

In the fall of 1972 Dr. Kristin Berry enlisted the members of the academic community, institutions and groups to write Mr. J. R. Penny, State Director of the Bureau of Land Management, in support of a "nature reserve" for the desert tortoise; a protected species and the California State reptile. Earlier Dr. Berry had found the California Department of Fish and Game and the Bakersfield office of the Bureau of Land Management responsive to the need to set aside an area of prime habitat. A proposed site was chosen on ten square miles of public land in the northern Mojave Desert.

The volume of supportive letters that arrived on Mr. Penny's desk must be interpreted as having set the pace for a rapidly expanding and fast moving project to protect the desert tortoise. The federated garden clubs of the Desert Empire District voted to support Dr. Berry and pledged $4,000.00 toward fencing for the proposed preserve. On April 4, 1974 these desert clubs went to work soliciting donations in exchange for plastic lapel pins and their motto was to H.A.V.E. F.A.I.T.H. By this time the need for an area much larger than ten square miles had been advised by consulting biologists and reptile specialists. Another twelve sections of public and private land were added, mostly to the south end. A year or so later, still another ten sections were added, making a total of 32 sections.

Having perceived the total commitment and genuine concern of the garden club members, Dr. Berry called a meeting on April 2, 1974 to discuss the feasibility of establishing a committee that might consolidate and continue the work begun by her. Interested individuals attended from all surrounding communities and from many walks of life. A group of 14 was picked to form the Desert Tortoise Preserve Committee. Backgrounds of the committee persons ranged from engineers - to biologists - to teachers - an R.N., and even an anthropologist.

The following goals were established:

1. Promote the welfare of the desert tortoise in the wild in the southwestern United States.

2. Establish a preserve as a natural area on the flanks of the western Rand Mountains and adjacent Fremont Valley in eastern Kern County, north of California City; and return and maintain the land in its natural state.

3. Protect the desert tortoise and promote its welfare on the preserve.

4. Raise funds for the establishment of the preserve; for the purchase of private land, fencing, and the development of a public use area.

5. Foster and publicize the uses of the preserve for selected forms of recreation, education, conservation and research.

These goals were written into the articles of incorporation of this Committee and they are solid, workable goals that have inspired the Committee members and thousands of people who have listened to their cause and made single donations that have ranged from one dollar to $4,800.00. The plastic pin sales soared and pins were sent to supporters in nearly every state in the Union.

News releases were handled by the Associated Press and the National Gardener. Audubon Societies, Sierra Club chapters, Humane Societies and turtle and tortoise clubs rallied in support of the Desert Tortoise Preserve.

Two, and sometimes three members of the Committee have been booked solid giving lectures and slide programs. A 35mm program is available on loan from the Committee. The Program Chairman made several television appearances in San Diego and Bakersfield and made video tapes. Twenty thousand brochures have been printed and distributed, and posters are used for exhibits and sales promotion. Guided tours during the spring months have been most helpful in educating the public of the need to preserve the area.

In the summer of 1975 the Committee started selling T-shirts. The whimsical face and catchy phrases front and back made the T-shirts an immediate "hit". Then the introduction of leather thong necklaces with ceramic medallion was timely. With these products the cash register began to ring up over $1,000 a month. Mind you, this small group of (now) 19 members were the salespeople and they recently added bolo ties and porcelin wind chimes to their product list. Donations continue to arrive in the mail daily.

By the time the Committee was 18 months old they had raised $24,000. Also at this time came word of the Sikes Act appropriation of $135,000. But all should realize these energetic fund-raising efforts were not the only function of the Committee.

During all of the time the Desert Tortoise Preserve Committee has been in existance there have been citizen's work sessions and the public input meetings to effect a Draft Management Framework Plan for the use of the El Paso - Rand Mountain area in which the Preserve is located. Certainly this statement is connotative of the Committee's effort to rally support for the Tortoise Preserve. From the continuing studies of reptile specialists and the fact that tortoise populations are deteriorating, new boundaries were proposed for the Preserve, which by the way is now being called the Desert Tortoise Natural Area. Acquiring any additional sections of national resource lands of course infuriates the off-road vehicle enthusiasts who declare all public lands should be available for their use.

Yes, there have been problems. But the objectives outlined at that organizational meeting are still the goals to be effected by the Committee. The sheep grazing on public and private land continues to be an open issue, although it has been proven over and over that stock grazing contributes to the decline of tortoise populations. The boundaries of the northern extension of the Preserve are under fire. There is plenty of visual evidence that motorcyclists are riding across a "closed natural area" - so designated as far back as November, 1973.

The Committee continually solicits support and protective controls by the Bureau of Land Management. A meeting held as recently as yesterday between Committee persons and the Bakersfield office of BLM resulted in the decision to have the Desert Tortoise

Preserve Committee design the interpretive facilities and the structures, and to determine the location for such displays; also to designate trails in the natural area. These activities, of course, will be possible due to the appropriation. And the supply and style of public information material will be upgraded - now that funds are available.

There are uphill battles to be won, however. The Bureau of Land Management may see fit to lop off the northern extension which is so very important to the development of the natural area. There are hundreds of acres of private inholdings to be purchased. But there are no weaklings on the Desert Tortoise Preserve Committee. As mentioned earlier, our goals are workable.

In conclusion, I'm pleased to have this opportunity to thank many of you for contributions already received and for those of you who would like to leave this Symposium with a momento of the Desert Tortoise Natural Area - the products are available from Committee members present.

Lastly, the Desert Tortoise Preserve Committee requests the Desert Tortoise Council to write a letter of endorsement in support of the Draft Management Framework Plan to include the northern extension.

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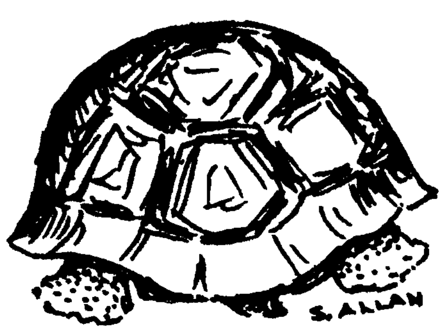

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DESERT TORTOISE COUNCIL
APPLICATION FOR MEMBERSHIP

DATE ______________________

NAME ______________________ PHONE ______________________
Please Print *Area Code*

ADDRESS ____
Street

____
City *State* *Zip Code*

I (We) hereby apply for the following membership:

( ) Regular ($5.00 per year) ( ) Patron ($100 or more -- lifetime)

( ) Student ($3.00 per year) ( ) Organization ($15.00 per year)

THE COUNCIL'S GOAL -- *To assure the continued survival of viable populations of desert tortoise throughout its existing range.*

Meetings will take place quarterly. You will be notified of the time and place. Place of meetings will be changed to allow members from all areas to participate. Minutes of each meeting will be sent to all members.

All checks or money orders should be made payable to the DESERT TORTOISE COUNCIL *and sent with the application to:*

Desert Tortoise Council
350 Golden Shore
Long Beach, California 90802