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DESERT TORTOISE HEAD STARTING PROJECT, EDWARDS AIR FORCE BASE, CALIFORNIA

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Abstract: In 2002, five predator-resistant portable pens were installed on Edwards Air Force Base, California. These pens were located on the Precision Impact Range Area in the south central portion of the base. Due to the time of year the pens were installed, the pens were not utilized until 2003. In 2003, 19 gravid adult female desert tortoises (*Gopherus agassizii*) were placed within the enclosures and allowed to deposit their eggs. A total of 40 eggs were obtained from these tortoises. The female tortoises were fitted with radio transmitters and released at their original capture locations after they had deposited their eggs within the pens. These eggs were allowed to incubate and develop within the pens while excluding natural predators that may normally predate on desert tortoise nests. In the fall of 2003, 32 hatchlings emerged from the nests. In September 2004, a total of eight yearlings were released from the pens. This paper documents procedures and the results of the first 2 years of this study.

Key words: desert tortoise, egg survivorship, *Gopherus agassizii*, hatchery, hatchling survivorship, head starting

INTRODUCTION

In 2001, Dr. David Morafka, with the California State University of Dominguez Hills, presented a management proposal to Edwards Air Force Base (AFB). This proposal involved installing predator-resistant portable enclosures on base at key locations where desert tortoise (*Gopherus agassizii*) populations had severely declined. These enclosures would be used to protect small-sized tortoises until they become large enough to exclude them from many of their natural predators. "Eggs and hatchlings are quite vulnerable, and pre-reproductive adult mortality averages 98%" (Wilbur and Morin 1988, Turner et al. 1987). Once large enough, they would be released from the pens to help augment the local population of tortoises here at Edwards AFB and increase the overall adult population.

Edwards AFB was selected as a study site, in part, for its stressed environment (upper respiratory track disease [URTD] is present), declining adult population, and low recruitment levels. Edwards AFB was also selected as a proposed site because of its large expanses of suitable desert tortoise habitat. This includes over 60,000 acres of critical desert tortoise habitat within the Fremont Kramer recovery unit.

In 2002, the predator-resistant portable enclosures, also called head starting pens, were installed on Edwards AFB; however, the enclosures were not used until 2003 due to the time of year the pens were installed (early summer). In 2003, Dr. Ken Nagy, with the Department of Ecology and Evolutionary Biology, University of California, Los Angeles (UCLA), became the primary researcher for this project.

In 2003, 19 gravid adult female desert tortoises were placed within the enclosures and allowed to deposit their eggs. Once the female tortoises had deposited their eggs, they were fitted with radio transmitters and released at their original capture locations. The eggs that were deposited were allowed to incubate and develop within the pens, while excluding natural predators that may normally predate on desert tortoise nests.

In September 2004, a total of eight yearlings were release from the pens. Two major questions this project will hopefully answer are:

1. What is the shortest amount of time needed to hold juvenile tortoises within these pens until they are reasonably resistant to predation?

2. Will supplemental irrigation increase the available food within the pens and decrease the amount of time needed to house these animals within the pens?

This report documents procedures and the results of the first 2 years of this project.

It is hoped that this project, if successful, can be duplicated and utilized throughout the Mojave Desert as a tool for land managers to help recover desert tortoise populations throughout their range.

SURVEY AREA

Edwards AFB is located in the Antelope Valley region of the western Mojave Desert in Southern California. It is approximately 60 miles northeast of Los Angeles, California (Figure 1). The base occupies an area of approximately 301,000 acres or 470 square miles. Portions of the base lie within Kern, Los Angeles, and San Bernardino Counties.

The head starting pens are located in the south central section of Edwards AFB on the Precision Impact Range Area (Figure 2). The pens are located within the Fremont/Kramer Desert Wildlife Management Area desert tortoise critical habitat (United States Fish and Wildlife Service 1994).

The pens are located within Los Angeles County in Township 8 North, Range 9 West, Section 24, of Rogers Lake South, California, United States Geological Survey Quadrangle 7.5' (1973).

Desert tortoise relative densities at the study site are 34 tortoises per square mile (Air Force Flight Test Center/Environmental Management 1996).

Soil over the study area are taxonomically classified in the Randsburg-Machone Outcrop complex, with a small percent in the Hi Vista Machone-Randsburg complex (United States Department of Agriculture [USDA] 1996). The soil morphology of both complexes consists of granitic residuum. This soil type has an erodibility factor of slight to moderate with regard to water erosion and moderate with regard to wind erosion. The Randsburg-Machone Outcrop complex permeability to water is moderately rapid, but the Hi Vista Machone-Randsburg complex permeability is moderately slow (USDA 1996).

Elevation at the study site ranged from 3,085 to 3,100 feet. The vegetation community at the study site is classified as a creosote bush (*Larrea tridentata*) scrub community (Mitchell et al. 1993). Additional plant species found in the study site are listed in Table 1.

METHODS

All activities are covered under United States Fish and Wildlife Service Scientific Collection Permit for Native Endangered and Threatened Wildlife Species Number TE085050-0. All animals were handled using *Guidelines for Handling Desert Tortoises during Construction Projects* (Desert Tortoise Council 1999).

Desert Tortoise Recovery Process

In early summer of 2002, five ARS-Vivant Modular-Moveable-Expandable Wildlife Protector System head starting pens were installed at Edwards AFB. These pens were designed at Mandla Design Associates by Robert Williams (Patent Number 6,532,701). Each pen is circular in design with an area of 2,900 square feet. The pens are constructed of chain link fencing with a plastic netting mesh material for the roof and a fine metal mesh at the bottom of the pens to exclude predators (Figure 3). These pens can be stand-alone or attached in a cluster formation together. At Edwards AFB, three of these pens are clustered together and two are stand alone.

In addition to these pens, there are five isolation pens located in close proximity to the head starting pens. These isolation pens are approximately 6 feet in diameter (Figure 4), approximately 2½ feet tall, and constructed of a metal mesh material with a small section covered with a cloth material for shade. These isolation pens were used to house female desert tortoises until their health status could be determined.

Both the head starting pens and isolation pens were installed by base volunteers and the project researchers from UCLA, in such a way that excluded most animals from entering or exiting the pens. Small mesh material was attached at

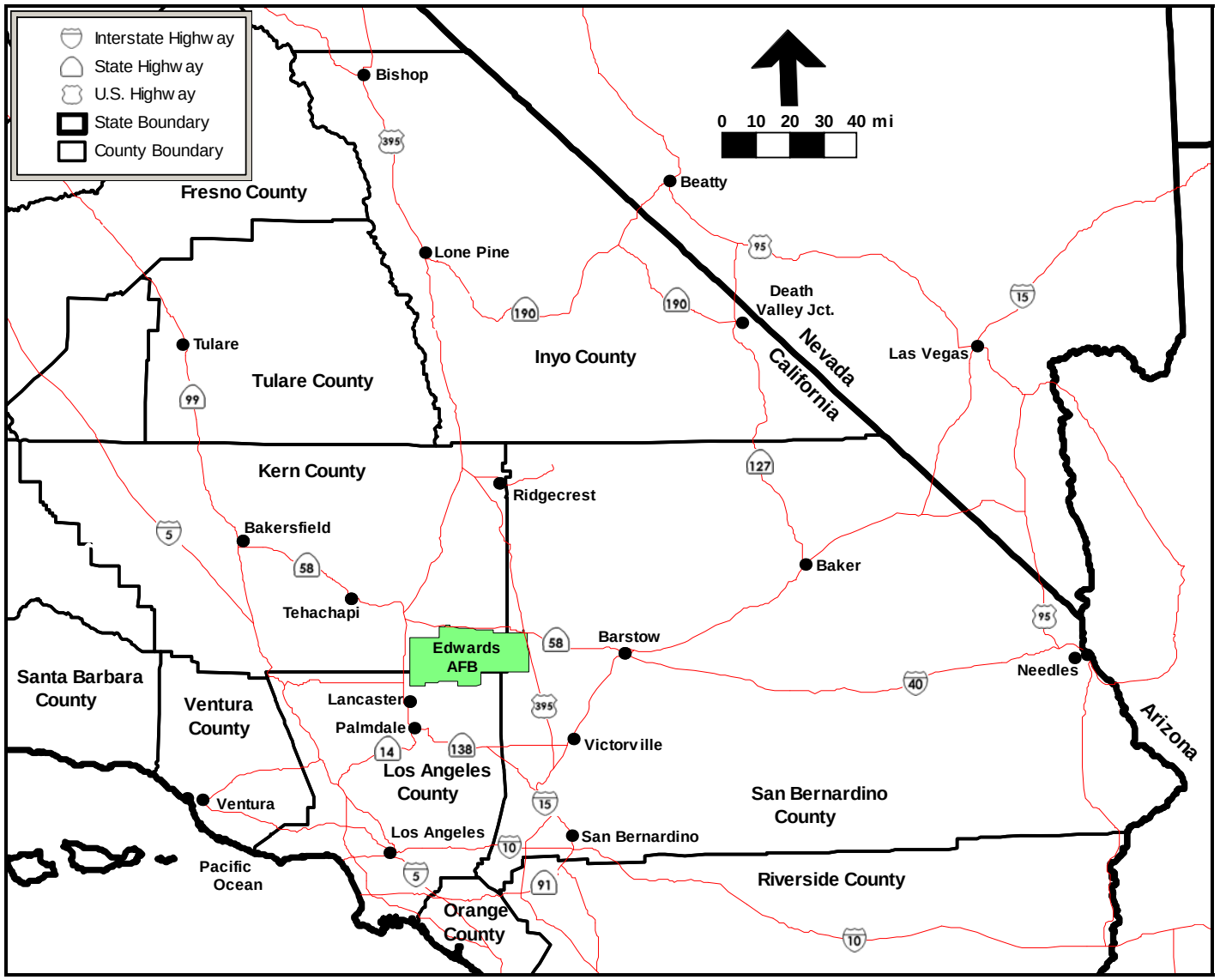

Figure 1. Location of Edwards Air Force Base

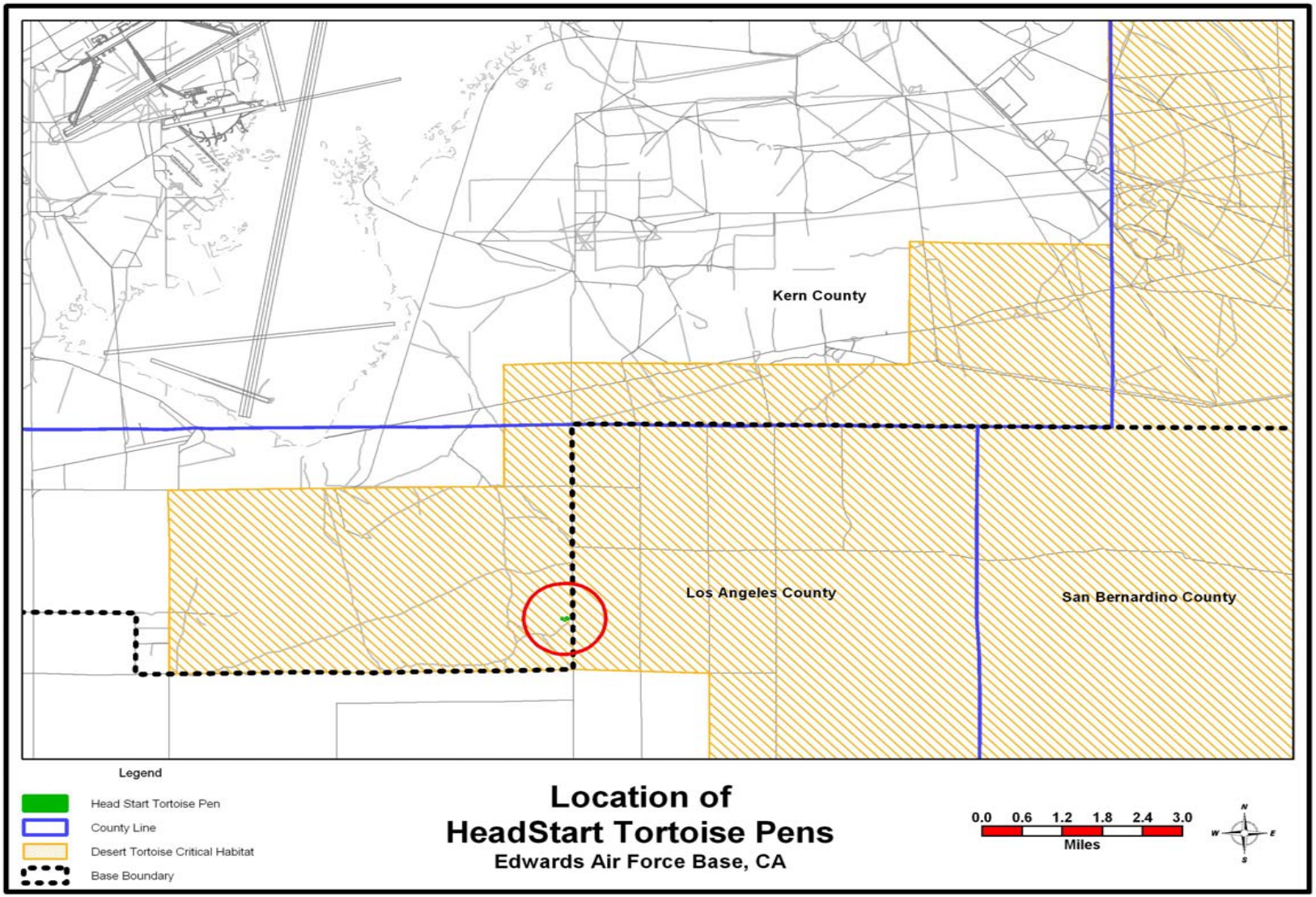

Figure 2. Location of Head Starting Pens

Table 1. Common Plant Species Observed Within the Study Area

Scientific Name	Common Name
Ambrosia dumosa	Burro-bush
Amsinckia tessellata	Fiddleneck
Ephedra nevadensis	Nevada tea
Erodium cicutarium	Red-stem filaree
Euphorbia albomarginata	Rattlesnake Spurge
Hymenoclea salsola	Cheesebush
Larrea tridentata	Creosote bush
Lasthenia californica	Goldfields
Lycium cooperi	Peach thorn
Phacalia crenulata	Purple phacelia
Poa secunda	Nevada bluegrass
Schismas barbatus	Split grass
Xylorhiza tortifolia	Mojave Aster

Figure 3. One of Five Head Starting Pens

Figure 4. Isolation Pen

the base of the pens and also buried subsurface to prevent animals from burrowing into or out of the pens.

Lastly, artificial burrows were constructed in both the isolation pens, as well as the head starting pens to provide shelter for the desert tortoises while inside the pens.

In the spring of 2003, 20 adult female desert tortoises were located in the wild, both on and off Edwards AFB lands; 19 were chosen for the study. The majority of the animals came from lands just south of the base (Figure 5). Local animals (animals close to the head starting pens) were used to the maximum extent possible to minimize genetic differences, behavior differences, and local adaptations.

When an animal was first located in the field, the animals original capture location was recorded using a global positioning system (GPS) unit so that the animal could be returned to its original capture site after the eggs were laid. A radio transmitter was attached to each individual animal so it could be tracked and relocated the following year.

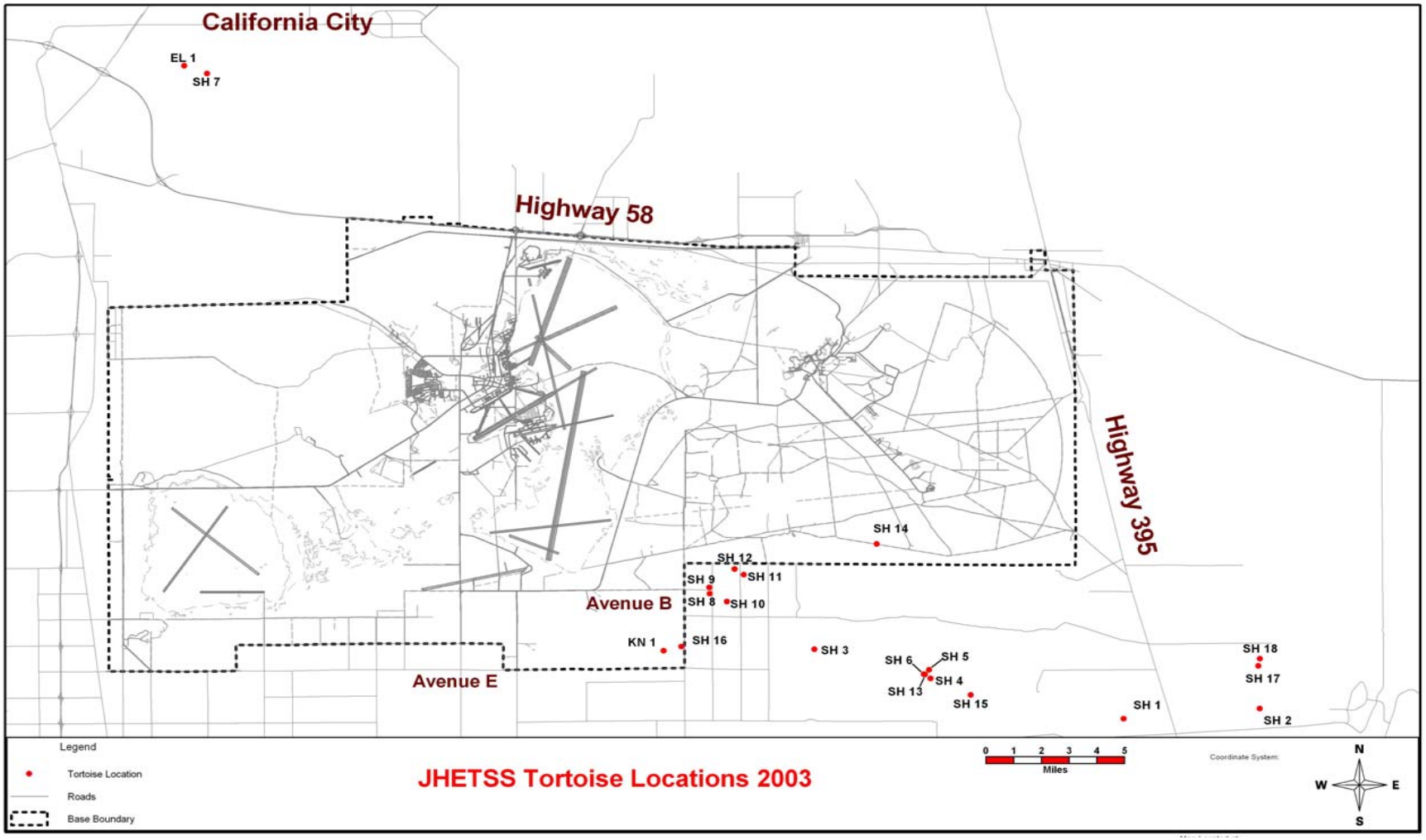

Figure 5. Locations of Wild Adult Female Tortoise

Once a female was located, the animal was x-rayed (using a portable x-ray machine) to determine their reproductive status (eggs present or not) and given a full health exam. When each female's reproductive status was determined, individuals showing eggs were transported to and placed in the individual isolation pens where they were tested for URTD and herpes viruses. Specifically, animals were tested for mycoplasma agassizii, testudo graeca, and testudo hermanni using enzyme-linked immunosorbent assay (ELISA) tests. All lab work was conducted by the University of Florida, Gainesville. Animals were left in the isolation pens until their disease status were determined. Once disease status was determined, animals were separated into the head starting pens. The two stand-alone pens were utilized for infected animals, one for URTD and one for the herpes virus. The remaining cluster of three head starting pens was for nondiseased animals. Animals not currently showing egg development were x-rayed again approximately every 2 weeks to determine if egg development was proceeding. When eggs began to show, the female was placed in an isolation pen and the procedure duplicated. If no eggs developed, the animal was removed from that year's study.

After the tortoises were placed within the head starting pens, they were monitored weekly until they deposited their eggs. Confirmation that a nest was constructed and eggs deposited within the nest was confirmed by two methods: change in the animals' weight and an x-ray to confirm the eggs were no longer present within the animal. After females deposited their eggs, they were returned to their original capture location and the cycle repeated the following year.

Plastic mesh rings were placed around each individual nest so that:

1. hatching success could be determined by individual animal,

2. paternity lineages could be established,

3. other adult female tortoises did not dig up another females nest, and

4. new neonates could be easily found when they emerged from the nest.

When neonates emerged in the fall (late August to early October), individuals were marked both on the plastron and carapace; and an individual number assigned to each animal. Also, each individual was carefully weighed and measured. All hatchlings were held within the pens at least 1 year before they were released.

Artificial Watering Experiment

In addition to placing animals into the head starting pens, a second component of this experimental study was performed concurrently. This involved artificially watering half of the nondiseased pens. The nondiseased pens were subdivided into four sections and half of the pens were artificially watered using a water truck, hose, and impulse sprinkler head twice per year. This artificial watering simulated approximately 1 inch of natural rainfall at each application. Water was applied by sprinklers to the pens when local annual plants begin to desiccate. The hypothesis for the experiment was that applying small amounts of water to annual plants would extend the growing season, extending the forage available to juvenile tortoises, allowing the animals to gain more energy for growth. Artificial water was not applied until the 2004 season, when juvenile animals were present within the pens.

RESULTS

Desert Tortoise Development

Of the 19 adult female tortoises that were placed in the head starting pens in 2003, one individual tested positive for URTD, three tested positive for herpes, and 15 were nondiseased animals. A total of 40 eggs were deposited in the pens in 2003, of which 32 hatched (80 percent hatchling success rate).

No offspring developed from the eggs deposited from the URTD positive female. A total of 12 hatchlings emerged from the eggs laid by the herpes positive females, and 20 nondiseased hatchlings emerged from eggs laid by the nondiseased adults.

All 2003 offspring were held in the pens until the fall of 2004, at which time only 20 animals

remained. Of the 20 animals that remained, 12 were from nondiseased mothers and 8 were from herpes-positive mothers.

It was determined that the eight 1-year-old herpes-positive offspring would be released in the fall of 2004. The remaining animals would remain in their pens for future releases. The yearlings were weighed and measured, and a radio transmitter and Passive Integrated Transponder (PIT) tag were attached to their carapace. On 29 September 2004, the eight animals were evenly dispersed just outside the pen enclosure. This placement was advised by the researchers to reduce homing behavior in the animals. The tortoises were placed in naturally-occurring, unoccupied rodent burrows at the base of creosote bushes. Scientists radio-tracked the animals weekly. Most animals stayed relatively close to their original release location; however, a few did move up to 82 feet away.

Desert Tortoise Survivorship

Of the eight yearlings released, none appear to have survived to date. Two died from predation. Four died from unknown reasons, but were not predated (most likely environmental factors). Their bodies were intact (no sign of predation) and dead animals were also found within the pens, indicating that freezing most likely killed these animals as well. The remaining two animals' transmitters failed and could not be located after several extensive searches of the area. These animals are suspected of being dead now, likely from predation, due to the fact that the animals were not found after their transmitters failed, when other juvenile tortoises were observed aboveground.

Of the eight yearlings that were released, only one individual survived more than 10 months (Figure 6). That one died of predation a few months later.

The individual weights, measurement, and body conditions of these eight released animals can be found in Table 2. In summary, four animals (50 percent) died, most likely from environmental factors; two (25 percent) died, most likely from predation; and two (25 percent) died from unknown causes (or could not be found). Most deaths occurred within the first 9 months of release. Predation occurred when tortoise activity was high (in the spring) when tortoises are most active.

Artificial Watering Experiment

Two waterings were provided to half of the clustered pens and simulated a total of 2 inches of natural rainfall. This artificial water extended the annual plants' lifespan several weeks, allowing for an extended forage season for juveniles, and also allowed the animals to obtain water if they desired. These waterings did not stimulate germination of any new plants, but only prolonged existing plant species. Waterings were conducted in late spring (one in May and one in early June). Health indices were conducted on all animals, both on the watered side and nonwatered side (dry side) of the pens throughout the year.

Data indicates that animals in the half of the pen that received an additional 2 inches of artificial rain had dramatically increased growth rates over nonwatered animals (Figure 7).

This additional 2 inches of artificial rain increased overall natural precipitation in the pens by 20 percent on the artificially watered side of the pen. Growth rates were more than doubled in the watered side of the pen compared to the nonwatered side.

CONCLUSION

It appears that first-year animals do not fair well when released. However, predation does not appear to be the only major cause of death. It appears that environmental factors, such as freezing, could also be a major cause of death in juvenile tortoises. However, due to the small sample size used, this experiment should be repeated and a larger sample size used.

The artificial watering experiment appears to hold promise. Growth rates more than doubled over the first year of life for individuals in the artificially watered side of the pen. This doubling

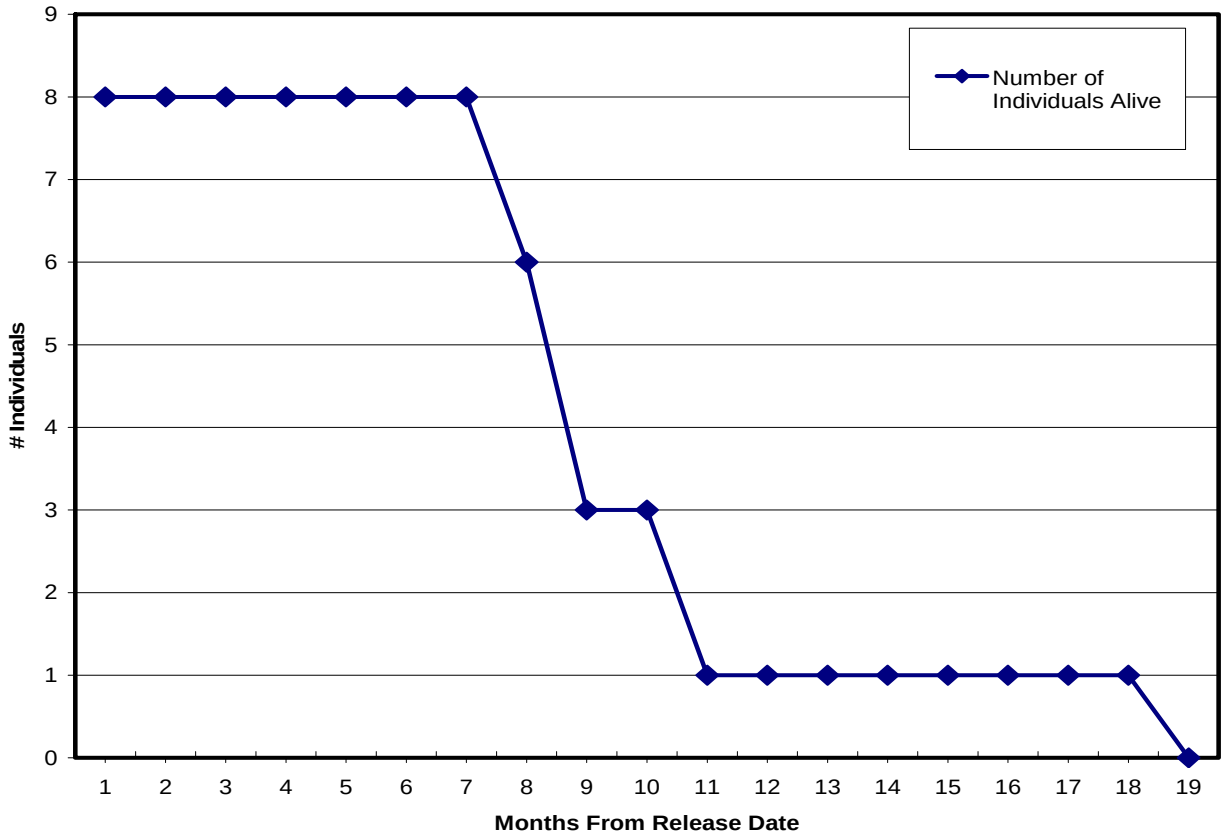

Figure 6. Survival of Released Yearling Desert Tortoises over Time

Table 2. Weights, Measurements, and Condition Indexes of the Eight Animals Released

Tort ID	Min CL (mm)	Height (mm)	Width (mm)	Mass (g)	CI (g/mm^3)
100	54.69	26.73	42.81	44.00	0.70
101	49.48	21.77	40.53	24.10	0.55
102	55.86	27.18	45.27	43.60	0.63
103	48.40	24.20	42.20	37.90	0.77
104	52.25	25.09	44.52	33.30	0.57
107	54.03	25.18	45.65	35.40	0.57
109	48.34	24.23	38.24	26.00	0.58
110	49.72	23.72	40.79	30.00	0.62

Notes: 1. Tort ID–tortoise identification
2. Min CL–Minimal Carapace Link
3. mm–millimeters
4. g–grams
5. CI–Condition Index
6. g/mm^3–grams per millimeter cubed

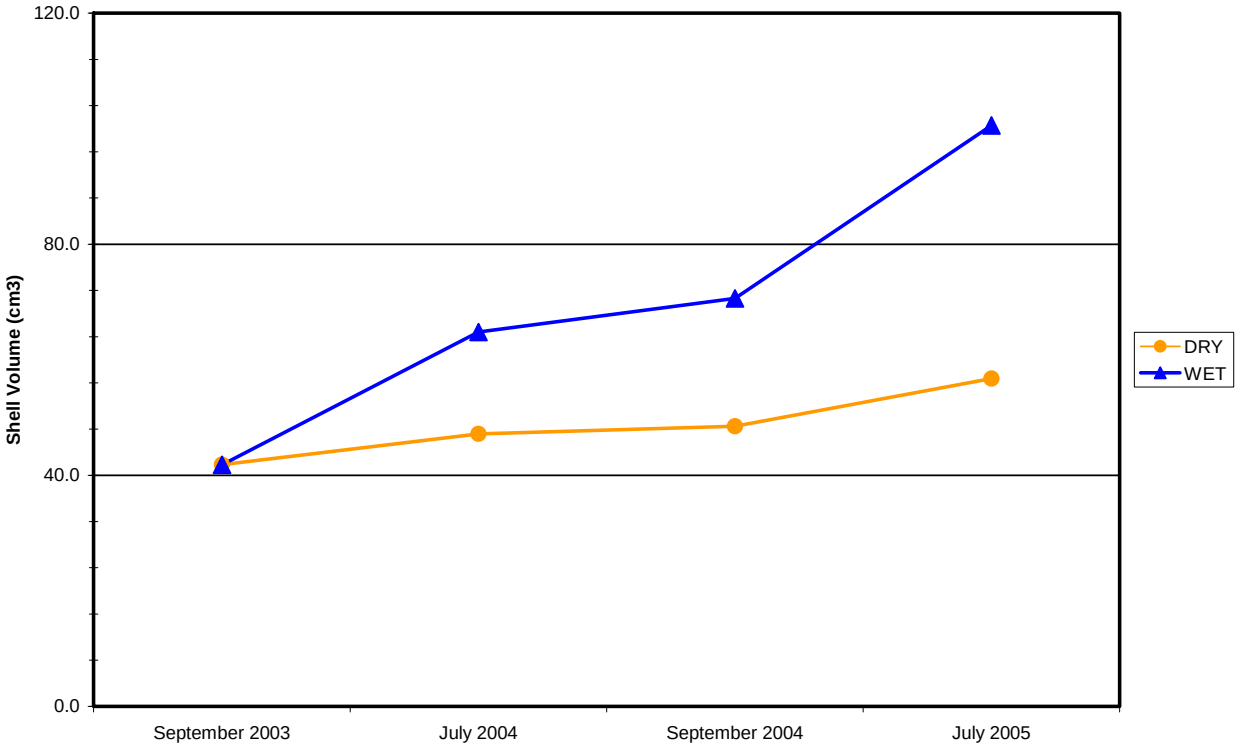

Figure 7 Increase in Shell Volume (cm3) of Juvenile Desert Tortoises in Dry and Wet Pens

of growth rate was achieved with a mere addition of 2 inches of rain or 20 percent more water than what naturally occurred at the site. Due to the apparent success of this experiment, it is recommended that the artificial watering continue and growth rates continue to be tracked.

Additional questions have arisen as a result of this study.

1. If predation is not the only major cause of death in juveniles and environmental factors have an influence on the cause of death, is there anything that can be done to increase survivorship in these animals?

2. Are juvenile offspring from diseased mothers not as fit as juvenile offspring from nondiseased mothers?

3. With artificial watering, it is apparent growth rates increase; however, what are the growth rates over time and how does this effect shell hardness?

4. Also, what is the fitness of animals with increased growth rates?

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