Open Journal of Animal Sciences, 2023, 13, 364-378
https://www.scirp.org/journal/ojas
ISSN Online: 2161-7627
ISSN Print: 2161-7597

Tropical Climates May Be Suitable for Endangered Desert Tortoise Exhibits, Rescues, Adoptions

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How to cite this paper: Richards, E. and Nogawski, J. (2023) Tropical Climates May Be Suitable for Endangered Desert Tortoise Exhibits, Rescues, Adoptions. *Open Journal of Animal Sciences*, **13**, 364-378.
https://doi.org/10.4236/ojas.2023.133027

Received: June 8, 2023
Accepted: July 25, 2023
Published: July 28, 2023

Abstract

Governmental, educational, environmental and other nonprofit organizations have placed efforts on conservation action for the threatened Mojave desert tortoise (*Gopherus agassizii*). While federal and state institutions have focused on the desert tortoise in its native habitat of the southwestern United States, there are other conservation groups whose work has been dedicated to the rescue, rehabilitation, rescue, placement and adoption of the desert tortoise in civilian homes and neighborhoods as well as sanctuaries, reserves and exhibits. AWAKE Community (AWAKE), a nonprofit organization dedicated to natural wildlife habitats and endangered species, has focused its research on desert tortoises in captivity. The California Turtle and Tortoise Club (CTTC), the official adoption arm of California's Department of Fish and Wildlife (CDFW), has provided instruction on methods of care for desert tortoises raised in captivity including housing, feeding, sexing, health and hibernation for both adults and hatchlings. AWAKE's research has been aimed at benefiting and supplementing the guidelines provided by CTTC, specifically for coastal climates. AWAKE's research has also aimed to provide insight to be considered for expanding adoption possibilities to other locations, specifically tropical climates, as adoption needs for desert tortoises have increased. This manuscript presents an analysis of one coastal and one tropical climate that can serve as a basis for: 1) understanding and evaluating climate in both existing and potential habitats for desert tortoise adoptions, rescues and exhibits, 2) providing insight and special instruction for desert tortoise adoptions in coastal communities, and 3) expanding awareness around desert tortoise needs in captivity.

Keywords

Desert Tortoise, Mojave Desert Tortoise, *Gopherus agassizii*, Tortoise

Adoptions, Threatened Species, Endangered Species, Desert Tortoises in Captivity, Desert Tortoise Climate

1. Introduction

The Mojave desert tortoise has been facing a conundrum as a species. Wild Mojave desert tortoises are moving closer to extinction in their native habitat yet growth in the captive desert tortoise population, through prohibited breeding, has created an increased need for adoptions of the species into human-controlled habitats. AWAKE Community (AWAKE) has focused its research on desert tortoise adoptions and the species' health in captivity which is largely climate dependent. The focal point of this paper is to share AWAKE's current study comparing the climate of two test locations, the coastal community of west Los Angeles and the eastern side of the tropical island of Kauai. The climate of each location is compared for the following purposes:

- To expand education about the requirements needed to maintain the health and well-being of desert tortoises adopted in the cooler climates of coastal California.
- To learn more about other possible geographic locations that may be suitable for desert tortoise exhibits, sanctuaries and adoptions in an era of climate change.
- To expand awareness about the differing needs of desert tortoises in captivity as compared to the needs of wild desert tortoises in their native desert habitat.

The Mojave population of desert tortoise (*Gopherus agassizii*) was first listed as threatened under the federal Endangered Species Act in 1990 [1]. In October 2020, the California Fish and Game Commission (CFGC) granted temporary uplisted endangered species status to the Mojave desert tortoise [2] in response to a petition filed by the Defenders of Wildlife [3] under the California Endangered Species Act (CESA) and a report submitted by the California Department of Fish and Wildlife (CDFW) [4] wherein it was determined the wild Mojave desert tortoise population in California has declined substantially from historical levels and has continued to trend downward since the species was listed as a threatened species by the CFGC in 1989.

The Mojave population of wild desert tortoises includes all tortoises north and west of the Colorado River in Arizona, Utah, Nevada and California. These tortoises in their native habitat are impacted by ongoing threats, including ever-increasing habitat loss, and also degradation and fragmentation of habitat due to urban, suburban and commercial development. Desert tortoises are negatively impacted by increasing wildfires due to human-introduced, invasive vegetation. Traffic on roads, highways, and freeways, as well as increasing off-road vehicle activity, has increased the road mortality of the desert tortoise. Increased predation of their eggs and hatchlings, spurred by human disruption to the natural order of the desert ecosystem, has decreased the desert tortoise's ability to recover from population loss in the wild. Additionally, the release of desert tortoises bred in captivity into the wild has greatly increased the spread of upper respiratory disease amongst wild desert tortoises.

The Mojave population of desert tortoise lives in a variety of southwestern United States desert habitats, including the sandy flats of dry desert washes to sloping, rocky foothills and canyons. In the wild, desert tortoises can hibernate in burrows for up to nine months annually, and is most active from March to June and September to October. In captivity, desert tortoises hibernate for just three to four months, often in climate-controlled locations, overseen by human caretakers. In coastal California communities, desert tortoises in captivity are ready to be wakened from hibernation in early March having started their annual brumation sometime in November or December.

US Fish & Wildlife Service describes the species: "The desert tortoise has a top shell that is brown, gray or black, and the shell underneath is lighter. The desert tortoise produces a variety of sounds—*hisses*, *grunts*, *pops*, *whoops*, *huhs*, *echs*, *bips*, etc. The desert tortoise has a short tail, flattened front legs that are adapted for digging, elephant-like hind legs and a high-domed shell and its shell height measures from 4 to 6 inches with its shell length measuring anywhere from 8 to 15 inches. Adult tortoises weigh eight to 15 pounds. Desert tortoises can live roughly 50 to 80 years, but take 13 to 20 years to reach sexual maturity. Desert tortoises eat various herbs, grasses, cacti and wildflowers" [1].

Desert tortoises are acknowledged to be a keystone species [5], which means other species in the ecosystem are largely dependent on them and that the disappearance of the desert tortoise would have a drastic impact on other species in the related environment. Many other species use the burrows dug by desert tortoises for shelter during harsh summer and cold winter conditions, including the Gila monster, collared peccaries, roadrunners, and burrowing owls. After desert tortoises digest, they disperse seeds from the native desert plants they ingest through their feces, which repopulates the flora and fauna of the desert ecosystem [6].

Desert tortoises eat a variety of grasses, cacti, shrubs, and wildflowers, and in times when water is scarce, receive much of their hydration from succulents. Desert tortoises rely on areas with a significant diversity of plant species for both food and protection from weather and predators. Fires in the desert have increased, both due to climate and also human ecosystem disruption, and can easily destroy the habitat of a desert tortoise that has not adapted as a species for fire. When fires are more frequent, diverse desert landscapes can become nonnative weed patches. Desert tortoises thrive in their desert environments with fully retractable heads and legs, protecting their body from predators, although certainly not from vehicles. The front legs of the desert tortoise emulate small shovels and the tortoise can readily dig into desert sand and dirt to build shelters for warmth on cool desert nights and shade on hot summer days. Once they reach adulthood, desert tortoises can live between 30 - 50 years in the wild, and some-times up to 80 years in captivity. It's estimated that desert tortoises have lived on earth for 15 to 20 million years [7], yet due to human behavior, desert tortoises are struggling for survival [8].

The purpose of this study is to introduce the Mojave desert tortoise as a species, to describe the history of threats to the Mojave desert tortoise in the wild, to highlight climate issues for desert tortoises in captivity, and to present AWAKE's climate research that suggests that tropical climates may present alternate habitat options for this species, which faces extinction in the wild but is growing in captivity, in an era of climate change.

2. Threat to the Desert Tortoise

The desert tortoise is listed as threatened, and is under review for uplisting to endangered status, because of significant losses and threats to tortoise populations and the development, disruption and fragmentation of desert tortoise habitat. In addition to the negative impacts described in Section 1 above, desert tortoises are directly impacted by increased raven predation on juveniles, collection by humans, vandalism, losses on roads and Off-Highway Vehicle (OHV) activities, and Upper Respiratory Tract Disease (URTD). Predation is the greatest cause of mortality for desert tortoise hatchlings and eggs which are eaten by Gila monsters, foxes, coyotes, snakes, and badgers. Juvenile tortoise shells do not fully harden until they reach the age of five or more years and young tortoises often fall prey to ravens, hawks, eagles, coyotes, foxes, bobcats, badgers, skunks, and feral dogs and cats. Up to 200 young tortoise carcasses have been found under raven perches and nests. Ravens peck tortoises at their shells and eat the animals' flesh inside. Fifty years ago, ravens were uncommon in the desert, but their population increased by 700 percent because of human activity. Under natural circumstances, the ravens would likely not survive the harsh desert environment, but because humans make food and water sources available, including landfills, illegal dumps, unsecured dumpsters and trash cans, man-made ponds, irrigation systems, and road kill, ravens have begun to thrive in harsh desert environments [9]. While considered unusual, coyotes, foxes, bobcats, eagles, and feral dogs have been known to prey on adult tortoises. Habitat quality can affect predation in certain habitats [10].

3. Desert Tortoise Adoptions

The southwestern states of Utah, Nevada, Arizona and California have desert tortoise adoption programs authorized by each state's Department of Fish and Wildlife. CDFW refers adoptions of, and licensing for, Mojave desert tortoises to the California Turtle and Tortoise Club (CTTC). CTTC Adoption Committees rescues, rehabilitates and place hundreds of desert tortoises into suitable homes each year [11], in 2021, there were 232 incoming desert tortoises managed by CTTC [12] chapters. Due to the population and resources of organizations and citizens in southern California urban areas, CTTC has focused significant adoption efforts in coastal communities like Los Angeles [13], Santa Barbara, Orange County, Long Beach, and San Luis Obispo [14].

The CTTC maintains a database of captive desert tortoises as well as processes and oversees the issuance of permits and registration for the "Permit to Possess Gopherus Tortoises" program [15], for which qualified individuals may apply [16]. The program enables the legal possession of a protected desert tortoise—which has a large captive population but is endangered in the wild—thereby discouraging the illegal taking of wild tortoises from their native habitat. This legal mechanism for desert tortoise possession and husbandry is essential in the endeavor to prevent civilians from returning captive tortoises to the wild, a once common practice that has contributed significantly to the spread of Upper Respiratory Tract Disease (URTD) in desert tortoises and that has devastated the wild population [17].

Despite restrictions on backyard breeding, desert tortoises are being born in "overwhelming numbers of clutches" according to Tortoise Group, the legal adoption nonprofit organization in Nevada [18]. Because a female tortoise in captivity is capable of laying 1 - 15 eggs in a single clutch, and up to three clutches in a single year, there is an increasing need for rescues and adoptions of desert tortoises for raising in captivity, thereby also protecting desert tortoises in the wild.

Climates in coastal southern California communities, where the number of desert tortoise adoptions continues to increase, are recorded as measurably cooler than those in the Mojave desert and have thereby presented health issues for the species resulting in challenges for caretakers. URTD is a significant issue for desert tortoises in captivity, worsened by cooler day and night temperatures and higher humidity.

4. Coastal California Climate Research

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AWAKE's California headquarters (aka the "Brentwood Urban Farm") is located in the western area of Los Angeles, on the border Brentwood and Santa Monica. AWAKE's research referenced in this paper focused on the climate of desert tortoises adopted into coastal communities that live and exist with consistently lower temperatures than those in their native Mojave desert in spring, summer and fall months (desert tortoises hibernate through the winter months each year).

In March of 2016, AWAKE adopted a Mojave desert tortoise (referred to as "George") through CTTC and was issued a permit to possess a desert tortoise by CDFW. Since 2016, AWAKE has engaged in research shared with the aim to assist caretakers of captive desert tortoises better maintain the health of the species under their stewardship.

AWAKE's hands-on experience in at the Brentwood Urban Farms has revealed man-made interventions—including moving the tortoise indoors overnight, providing heatlamps and warm baths—are often required to maintain the health and well-being of a desert tortoise in a coastal community of California due to cool temperatures.

AWAKE has collected climate data for western Los Angeles from the Los Angeles International Airport Station [19] for each day for the months March through November, for the years 2021 and 2022, and the months March and April of 2023 (and will continue collecting the same data for May through November of 2023). Because desert tortoises hibernate December through March annually, data was not collected for those months for this report. A summary of the temperature data collected as part of AWAKE's research is presented in **Table 1**.

Of the 611 days monitored in March 2021 through April 2023, 458 of those required heating lamps and/or warm baths for the desert tortoise "George" under the care of AWAKE at its Brentwood Urban Farm in western Los Angeles. These manmade warming methods were required for the tortoise habitat to reach the temperature required for a desert tortoise to move, eat, digest, process calcium and vitamin D, and maintain respiratory health. AWAKE shares this data as a guide for other caretakers of desert tortoises in similar climates.

AWAKE's daily climate data collection from the Los Angeles International Airport Station [19] for March through November, for 2021 and 2022, and the months March and April of 2023 is summarized in **Table 2**.

AWAKE currently shares this data with CTTC and has begun circulating it with individuals and organizations that adopt desert tortoises so that stewards of desert tortoises in captivity have additional insight in order to provide specialized care in coastal communities where cooler temperatures are pervasive, when compared to California deserts and valleys.

5. Kauai Climate Research

AWAKE is the process of relocating its headquarters from the Brentwood Urban Farm to Shambhala Gardens in Kilauea, Kauai, thus giving AWAKE the impetus to compare the tropical climate of Kauai to the coastal climate of western Los Angeles. AWAKE has collected climate data for Kauai from the Lihue Airport Station [20] for each day for the months March through November, for the years 2021 and 2022, and the months March and April of 2023 (and will continue collecting the same data for May through November of 2023). Because desert tortoises hibernate December through March annually, data was not collected for those months. A summary of the temperature data collected as part of that research is presented in **Table 3**.

Of the 611 days monitored in March 2021 through April 2023, only 34 of those never reached temperatures of 75 degrees as compared with Los Angeles,

Table 1. AWAKE Community LAX temperature data Mar 2021-Apr 2023, excluding hibernation months of Nov-Feb.

Temperature Summary Los Angeles			
2021	Totals Days Monitored	275	
	Total days temperature ≥ 75	61	22%
	Total days temperature ≥ 85	10	4%
2022	Totals Days Monitored	275	
	Total days temperature ≥ 75	90	33%
	Total days temperature ≥ 85	13	5%
2023	Totals Days Monitored (Mar, Apr)	61	
	Total days temperature ≥ 75	2	3%
	Total days temperature ≥ 85	0	0%
2021, 2022, 2023	Totals Days	611	100%
	Total days ≥ 75	153	25%
	Total days ≥ 85	23	4%
	Days below 85 degrees	588	96%
	Days below 75 degrees	458	75%

Table 2. AWAKE Community LAX climate data Mar 2021-Apr 2023, excluding hibernation months of Nov-Feb.

Month	Location	Temperature (˚F)			Dew Point (˚F)			Humidity (%)			Wind Speed (mph)			Pressure (in)			Precipitation (in)
		Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Total
2021																	
Mar	LAX	64	56	49	47	42	35	83	64	41	19	8	0	30	30	30	1.32
Apr	LAX	67	60	55	52	49	44	84	69	52	17	8	0	30	30	30	0.00
May	LAX	67	61	57	55	53	51	86	74	61	16	8	1	30	30	30	0
Jun	LAX	68	63	59	57	55	53	87	75	60	15	8	1	29	29	29	0
Jul	LAX	73	68	62	63	62	58	92	81	65	16	8	0	30	30	30	0
Aug	LAX	77	71	67	65	63	61	93	80	63	16	8	0	31	31	31	0
Sep	LAX	71	65	61	59	57	55	85	73	57	15	7	0	29	29	29	0
Oct	LAX	72	65	58	60	52	41	90	69	41	15	7	0	30	30	30	0
Nov	LAX	69	61	55	52	46	40	82	64	45	11	5	0	29	29	29	0
9 mo avg	**LAX**	**70**	**63**	**58**	**57**	**53**	**49**	**87**	**72**	**54**	**16**	**7**	**0**	**30**	**30**	**30**	**0.21**
2022																	
Mar	LAX	68	60	53	52	47	39	85	66	42	17	8	1	30	30	30	1
Apr	LAX	68	61	55	52	47	42	80	63	45	18	9	1	29	29	29	0
May	LAX	69	63	58	55	52	48	83	70	55	17	8	0	30	30	30	0
Jun	LAX	73	67	63	60	59	57	87	76	62	16	8	1	30	30	30	0
Jul	LAX	74	68	64	62	61	59	88	77	63	16	8	1	30	30	30	0

Continued

Aug	LAX	77	71	67	64	62	59	87	74	59	16	8	1	30	30	30	0
Sep	LAX	82	75	69	67	64	61	86	71	53	16	8	0	30	30	30	0
Oct	LAX	64	57	50	51	46	40	87	70	49	12	6	0	30	30	30	2
Nov	LAX	69	60	51	52	42	32	83	58	35	15	7	0	30	30	30	2
9 mo avg	**LAX**	**71**	**65**	**59**	**57**	**53**	**49**	**85**	**69**	**51**	**16**	**8**	**0**	**30**	**30**	**30**	**0.57**
2023*																	
Mar	LAX	61	55	50	51	46	41	88	74	58	17	9	1	30	30	30	8
Apr	LAX	65	58	53	52	49	45	89	75	57	16	8	0	30	30	30	0
May	LAX																
Jun	LAX																
Jul	LAX																
Aug	LAX																
Sep	LAX																
Oct	LAX																
Nov	LAX																
2 mo avg	**LAX**	**63**	**57**	**52**	**51**	**47**	**43**	**89**	**74**	**57**	**17**	**8**	**1**	**30**	**30**	**30**	**3.83**

*2023 months May-Nov to be collected in the future.

Table 3. AWAKE Community LIH temperature data Mar 2021-Apr 2023, excluding hibernation months of Nov-Feb.

Temperature Summary Kauai			
2021	Totals Days Monitored	275	
	Total days temperature ≥ 75	265	96%
	Total days temperature ≥ 85	75	27%
2022	Totals Days Monitored	275	
	Total days temperature ≥ 75	251	91%
	Total days temperature ≥ 85	43	16%
2023	Totals Days Monitored (Mar, Apr)	61	
	Total days temperature ≥ 75	61	100%
	Total days temperature ≥ 85	0	0%
2021, 2022, 2023	Totals Days	611	100%
	Total days ≥ 75	577	94%
	Total days ≥ 85	118	19%
	Days below 85 degrees	493	81%
	Days below 75 degrees	34	6%

where 458 days never reached 75 degrees. The temperatures recorded on Kauai are much closer to those required for desert tortoise optimal health.

AWAKE's other daily climate data collection for the same time period and location as stated above is summarized in **Table 4**.

An aspect of AWAKE's mission, and one of its programs, researches man-made interventions for species that have become threatened and endangered largely through human activity [21], with the hypothesis that if it is human activity causing the decline of a species, inverse human assistance may help reverse the species decline.

In some scenarios, intentional aid given to species negatively impacted by human activity has had unexpected benefits on the surrounding environment and other species. One such case is at the Makauwahi Cave Reserve on Kaua'i [22] where unwanted sulcata tortoises in need of rescue were provided habitat on the reserve. Now, over 10 sulcata tortoises control invasive weeds and improve soil fertility at Makauwahi Cave on the south shore of Kauai, while providing habitat for tortoises that emulate behaviors of Kauai's extinct giant ducks and geese [23].

AWAKE is not suggesting that the desert tortoise will provide a benefit to the island of Kauai nor is AWAKE proposing to attempt any such project. AWAKE is conducting its study of the desert tortoise on the island through observation of only a singular desert tortoise in a secured environment removed from the ecosystem under strict biological control. It is important to note that several non-native species introduced to Hawaii, which were not evaluated nor under biological control, have negatively impacted native forests and species [24]. One such import, the Indian Mongoose, was introduced to Hawaii in 1883 by the sugar industry to control rats, however, the Mongoose have made little impact on controlling the rodents and rather, have negatively impacted native birds, sealife, insects, and animals [25].

AWAKE is hypothesizing that Kauai provides a potential test environment wherein it is possible to explore the impact of a tropical climate on a desert tortoise, so that similar climate zones may be considered for establishing desert tortoise exhibits, rescues, and sanctuaries under biological control. Additionally, the research AWAKE proposes to conduct on Kauai may provide unexpected insight that could possibly aid in the preservation of this species, both in captivity and in the wild, as the status of the desert tortoise continues to decline in its native habitat.

6. Comparative Climate Assessment

AWAKE compiled the daily climate data for both Los Angeles, California and Lihue, Kauai in **Tables 1-4**, and then compared and contrasted this datain **Tables 5-7**.

With this comparative analysis there are several noteworthy statistics:

- Average daily high temperatures in Lihue fell between the suggested 70 - 90 degree daytime guideline [26] for desert tortoises in captivity for all 20 months collected.

Table 4. AWAKE Community LIH climate data Mar 2021-Apr 2023, excluding hibernation months of Nov-Feb.

Month	Location	Temperature (˚F)			Dew Point (°˚F)			Humidity (%)			Wind Speed (mph)			Pressure (in)			Precipitation (in)
		Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Total
2021																	
Mar	LIH	76	71	68	68	65	62	92	81	69	23	17	11	30	30	30	11.88
Apr	LIH	79	72	69	67	63	58	86	72	61	18	13	7	30	30	30	1.55
May	LIH	81	76	71	70	68	65	87	76	63	18	13	8	30	30	30	0.36
Jun	LIH	81	75	72	69	67	65	84	72	59	17	12	6	29	29	29	1.01
Jul	LIH	85	80	76	73	70	65	86	74	58	20	15	10	30	30	30	1.71
Aug	LIH	89	83	79	75	73	71	85	74	62	19	14	9	31	31	31	1.30
Sep	LIH	81	76	73	71	68	64	86	74	60	19	14	8	29	29	29	1.83
Oct	LIH	81	76	73	71	68	64	86	74	60	19	14	8	29	29	29	1.83
Nov	LIH	79	73	66	69	66	60	90	78	60	15	10	5	29	29	29	0.91
9 mo avg	**LIH**	**81**	**76**	**72**	**70**	**68**	**64**	**87**	**75**	**61**	**19**	**14**	**8**	**30**	**30**	**30**	**2.49**
2022																	
Mar	LIH	78	73	68	69	67	64	94	83	68	16	11	5	30	30	30	3.33
Apr	LIH	78	72	71	70	67	61	94	82	67	21	16	10	30	30	30	1.53
May	LIH	80	74	71	71	67	66	93	79	70	18	13	9	30	30	30	2.70
Jun	LIH	79	74	71	70	68	66	94	82	68	17	13	8	30	30	30	0.44
Jul	LIH	84	79	75	71	69	67	84	73	61	20	15	10	30	30	30	0.95
Aug	LIH	83	77	72	72	70	68	91	80	67	17	12	7	30	30	30	2.19
Sep	LIH	85	79	74	73	71	69	89	77	64	15	11	5	30	30	30	0.65
Oct	LIH	74	68	63	61	58	54	87	73	56	15	7	0	30	30	30	0.24
Nov	LIH	81	75	72	70	67	65	87	74	63	20	15	9	30	30	30	1.10
9 mo avg	**LIH**	**80**	**74**	**71**	**70**	**67**	**65**	**90**	**78**	**65**	**18**	**12**	**7**	**30**	**30**	**30**	**1.46**
2023																	
Mar	LIH	80	74	69	70	67	64	90	78	65	18	11	3	30	30	30	4.97
Apr	LIH	79	73	63	70	67	59	92	81	64	18	12	5	30	30	30	6.05
May	LIH																
Jun	LIH																
Jul	LIH																
Aug	LIH																
Sep	LIH																
Oct	LIH																
Nov	LIH																
2 mo avg	**LIH**	**79**	**74**	**66**	**70**	**67**	**61**	**91**	**79**	**64**	**18**	**12**	**4**	**30**	**30**	**30**	**5.51**

Table 5. AWAKE Community LAX v LIH climate data Mar-Nov 2021.

Month	Location	Temperature (˚F)			Dew Point (˚F)			Humidity (%)			Wind Speed (mph)			Pressure (in)			Precipitation (in)
		Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Total
2021																	
Mar	LAX	64	56	49	47	42	35	83	64	41	19	8	0	30	30	30	1.32

Continued

Mar	LIH	76	71	68	68	65	62	92	81	69	23	17	11	30	30	30	11.88
Mar	LIH > LAX	12	15	19	20	23	28	9	16	28	4	8	11	0	0	0	10.56
Apr	LAX	67	60	55	52	49	44	84	69	52	17	8	0	30	30	30	0.00
Apr	LIH	79	72	69	67	63	58	86	72	61	18	13	7	30	30	30	1.55
Apr	LIH > LAX	12	12	14	15	14	13	1	3	9	1	5	6	0	0	0	1.55
May	LAX	67	61	57	55	53	51	86	74	61	16	8	1	30	30	30	0
May	LIH	81	76	71	70	68	65	87	76	63	18	13	8	30	30	30	0
May	LIH > LAX	15	14	14	15	15	15	1	2	2	2	5	7	0	0	0	0.36
Jun	LAX	68	63	59	57	55	53	87	75	60	15	8	1	29	29	29	0
Jun	LIH	81	75	72	69	67	65	84	72	59	17	12	6	29	29	29	1
Jun	LIH > LAX	13	13	13	12	11	11	−3	−3	−1	2	5	6	0	0	0	1.01
Jul	LAX	73	68	62	63	62	58	92	81	65	16	8	0	30	30	30	0
Jul	LIH	85	80	76	73	70	65	86	74	58	20	15	10	30	30	30	2
Jul	LIH > LAX	12	12	14	11	8	6	−5	−8	−7	5	7	9	0	0	0	1.59
Aug	LAX	77	71	67	65	63	61	93	80	63	16	8	0	31	31	31	0
Aug	LIH	89	83	79	75	73	71	85	74	62	19	14	9	31	31	31	1
Aug	LIH > LAX	12	12	13	11	10	10	−8	−5	−1	3	6	8	0	0	0	1.28
Sep	LAX	71	65	61	59	57	55	85	73	57	15	7	0	29	29	29	0
Sep	LIH	81	76	73	71	68	64	86	74	60	19	14	8	29	29	29	2
Sep	LIH > LAX	10	11	12	12	11	9	2	1	3	5	7	8	0	0	0	1.83
Oct	LAX	72	65	58	60	52	41	90	69	41	15	7	0	30	30	30	0
Oct	LIH	81	76	73	71	68	64	86	74	60	19	14	8	29	29	29	2
Oct	LIH > LAX	9	11	14	11	16	23	−4	5	19	4	7	8	−1	−1	−1	1.37
Nov	LAX	69	61	55	52	46	40	82	64	45	11	5	0	29	29	29	0
Nov	LIH	79	73	66	69	66	60	90	78	60	15	10	5	29	29	29	1
Nov	LIH > LAX	10	12	12	17	20	21	9	13	15	4	5	5	0	0	0	0.91
9 mo avg	**LIH > LAX**	**12**	**13**	**14**	**14**	**14**	**15**	**0**	**3**	**7**	**3**	**6**	**8**	**0**	**0**	**0**	**2.27**

Table 6. AWAKE Community LAX v LIH climate data Mar-Nov 2022.

Month	Location	Temperature (˚F)			Dew Point (˚F)			Humidity (%)			Wind Speed (mph)			Pressure (in)			Precipitation (in)
2022		Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Total
Mar	LAX	68	60	53	52	47	39	85	66	42	17	8	1	30	30	30	1
Mar	LIH	78	73	68	69	67	64	94	83	68	16	11	5	30	30	30	3
Mar	LIH > LAX	10	13	15	17	20	25	9	17	26	−1	3	4	0	0	0	2.23
Apr	LAX	68	61	55	52	47	42	80	63	45	18	9	1	29	29	29	0
Apr	LIH	78	72	71	70	67	61	94	82	67	21	16	10	30	30	30	2
Apr	LIH > LAX	10	12	16	18	20	20	14	19	22	3	7	9	1	1	1	1.30

Continued

May	LAX	69	63	58	55	52	48	83	70	55	17	8	0	30	30	30	0
May	LIH	80	74	71	71	67	66	93	79	70	18	13	9	30	30	30	3
May	LIH > LAX	11	11	13	16	14	18	10	9	15	1	5	8	0	0	0	2.70
Jun	LAX	73	67	63	60	59	57	87	76	62	16	8	1	30	30	30	0
Jun	LIH	79	74	71	70	68	66	94	82	68	17	13	8	30	30	30	0
Jun	LIH > LAX	7	7	8	10	9	9	7	6	7	1	5	7	0	0	0	0.43
Jul	LAX	74	68	64	62	61	59	88	77	63	16	8	1	30	30	30	0
Jul	LIH	84	79	75	71	69	67	84	73	61	20	15	10	30	30	30	1
Jul	LIH > LAX	10	11	11	9	9	8	−3	−4	−2	4	7	10	0	0	0	0.95
Aug	LAX	77	71	67	64	62	59	87	74	59	16	8	1	30	30	30	0
Aug	LIH	83	77	72	72	70	68	91	80	67	17	12	7	30	30	30	2
Aug	LIH > LAX	6	6	6	8	8	9	5	6	7	0	4	6	0	0	0	2.19
Sep	LAX	82	75	69	67	64	61	86	71	53	16	8	0	30	30	30	0
Sep	LIH	85	79	74	73	71	69	89	77	64	15	11	5	30	30	30	1
Sep	LIH > LAX	3	4	5	6	7	8	2	6	11	−1	3	5	0	0	0	0.52
Oct	LAX	64	57	50	51	46	40	87	70	49	12	6	0	30	30	30	2
Oct	LIH	74	68	63	61	58	54	87	73	56	15	7	0	30	30	30	0
Oct	LIH > LAX	11	11	13	10	12	14	0	3	7	2	1	0	0	0	0	−1.68
Nov	LAX	69	60	51	52	42	32	83	58	35	15	7	0	30	30	30	2
Nov	LIH	81	75	72	70	67	65	87	74	63	20	15	9	30	30	30	1
Nov	LIH > LAX	12	15	20	18	25	33	4	17	29	6	8	9	0	0	0	−0.67
9 mo avg	**LIH > LAX**	**9**	**10**	**12**	**13**	**14**	**16**	**5**	**9**	**13**	**2**	**5**	**7**	**0**	**0**	**0**	**0.89**

Table 7. AWAKE Community LAX v LIH climate data Mar-Apr 2023, May-Nov to be collected.

Month	Location	Temperature (˚F)			Dew Point (˚F)			Humidity (%)			Wind Speed (mph)			Pressure (in)			Precipitation (in)
2023		Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Total
Mar	LAX	61	55	50	51	46	41	88	74	58	17	9	1	30	30	30	8
Mar	LIH	80	74	69	70	67	64	90	78	65	18	11	3	30	30	30	5
Mar	LIH > LAX	19	19	19	19	21	23	1	5	7	2	2	2	0	0	0	−2.59
Apr	LAX	65	58	53	52	49	45	89	75	57	16	8	0	30	30	30	0
Apr	LIH	79	73	63	70	67	59	92	81	64	18	12	5	30	30	30	6
Apr	LIH > LAX	14	15	10	18	18	14	3	6	7	2	5	5	0	0	0	5.96
May	LAX																
May	LIH																
May	LIH > LAX																
Jun	LAX																
Jun	LIH																

Continued

Jun	LIH > LAX																
Jul	LAX																
Jul	LIH																
Jul	LIH > LAX																
Aug	LAX																
Aug	LIH																
Aug	LIH > LAX																
Sep	LAX																
Sep	LIH																
Sep	LIH > LAX																
Oct	LAX																
Oct	LIH																
Oct	LIH > LAX																
Nov	LAX																
Nov	LIH																
Nov	LIH > LAX																
2 mo avg	**LIH > LAX**	**17**	**17**	**14**	**19**	**19**	**18**	**2**	**5**	**7**	**2**	**3**	**4**	**0**	**0**	**0**	**2**
		12		13				2	6	9							

- Average daily high temperatures in Los Angeles fell below the suggested 70 - 90 degree daytime guideline for 12 of the 20 months collected, averaging above 80 degrees in only one of those 20 months.
- Lihue daily high temperatures averaged 12 degrees warmer than daily high temperatures in Los Angeles for the collection period.
- The overall maximum humidity in Lihue averaged just 3 percentage points higher than that of the overall maximum humidity in Los Angeles.
- The average maximum and minimum barometric pressure of both Kauai and Los Angeles was identical, with zero percent difference.

7. Conclusion

The research summarized herein was conducted to provide insight into desert tortoise rescues and adoptions. The Mojave desert tortoise could be moving from threatened to endangered status in the state of California [3] and it is evermore imperative that desert tortoises in captivity are not released into the wild [18] to avoid introducing infection and weaker genetics strains to the species and ecosystem [18]. The Desert Tortoise Council hosts regular symposiums to share scientific research and papers on a far and wide spectrum of issues facing the desert tortoise [27] encouraging organizations to conduct both central and outlying research to share. Because the need for desert tortoise adoptions is rising while at the same time, the status of the species in the wild is declining, there are unique problems to be solved with desert tortoise adoptions. AWAKE has performed, and continues to collect, climate research to highlight potential climates and geographic locations that may be suitable for desert tortoise health. Considering new possibilities for desert tortoise exhibits (zoos, sanctuaries, reserves, etc.) outside the native species' habitat can not only aid in the caretaking of the desert tortoise, but can also provide new opportunities for education about desert tortoises in a wider population thereby increasing awareness and consciousness about the struggle of the desert tortoise—both in the wild and now also in captivity.

Acknowledgements

AWAKE thanks Karen Berry, CTTC's Director of Adoptions (Valley Chapter) for providing information, guidance and support for this project. AWAKE thanks Dr. Frank Lavac, Director of VCA Wilshire Animal Hospital and Exotics Specialist, for his guidance, healthcare and support for this project.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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