Warm air leads to hazardous ground temperatures when walking dogs in built and natural environments

Paul F. Hudak

Abstract: Two case studies in Texas, one in a built environment and another in a natural setting, illustrate potential ground heat hazards when walking dogs on warm days. In the first case, temperatures of four different ground surfaces—concrete, grass, chip seal, and tar—were measured along a street in a suburban neighborhood. The study involved two morning and two afternoon surveys of 30 sampling locations where all four materials were present. Air temperatures, typical of the study area in summer, ranged from 78.0 oF (25.6 oC) in the morning to 96.1 oF (35.6 oC) in the afternoon. Ground surfaces reached much higher temperatures, exceeding 150 oF (65.6 oC), in the afternoon surveys. Median temperatures were highest in tar, followed by chip seal, concrete, and grass. The second case involved shallow lake water and various types of mud, sand, cobbles, rock fragments, and grass along a nature trail. Air temperatures ranged from 74.7 oF (23.7 oC) at 8:00 a.m. to 92.5 oF (33.6 oC) at 6:00 p.m. Ground temperatures varied considerably with material and time of day, ranging from 76.4 oF (24.7 oC) at gray cobbles and beige rock at 8:00 a.m. to 125.7 oF (52.1 oC) at brown sand at 4:00 p.m. Over the day, temperatures were highest at brown sand and lowest in water and moist sand.

Keywords: dog; ground; heat; walking; welfare

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HIGHLIGHTS

- Two case studies document potentially dangerous ground temperatures along walking paths in built and natural environments.
- The study adds to our understanding of temperatures attained by various ground materials during warm weather.
- The study helps pet owners understand harmful conditions their animals may encounter when walking.

INTRODUCTION

Dog walking is an important form of human-animal interaction in urban and suburban settings worldwide. Healthy effects of walking dogs are well established. Owning and walking dogs contributes to physical, mental, and emotional health, while providing an important form of social support (Cutt et al. 2007). In a study of 536 individuals, dog walkers had more physical activity and lower chances of diabetes, hypertension, hypercholesterolemia, and depression (Lentino et al. 2012). Another study documented more frequent moderate and vigorous exercise, lower body mass index, and fewer ailments requiring doctor visits for dog walkers (Curl et al. 2017). Strong dog-owner relationships tend to correlate with positive mental outcomes when walking dogs. Frequent dog walkers reported feelings of happiness, contingent on the perception that dogs enjoyed the experience (Westgarth et al. 2017).

Regular walking benefits both children and adults, as well as dogs. Older adults benefit from increased physical activity and a heightened sense of community to an extent that supports healthy aging (Toohey et al. 2013). Adolescents who walked and played with dogs more often met national physical activity recommendations in Western countries (Martin et al. 2015). Children in families with dogs tend to have higher levels of physical activity (Owen et al. 2010; Engelberg et al. 2015). Furthermore, dogs that regularly exercise tend to maintain healthier weight (German et al. 2017).

While ample research demonstrates the benefits of dog walking, fewer studies document adverse outcomes, including those affecting dogs. Potentially harmful situations include over exertion, salt in cold areas, and extreme temperatures (Bender 2019), which can lead to dehydration and potentially stroke (Foley 2015; Hall et al. 2020), as well as damage to paws, including abrasion, chapping, cracking, sores, blisters, and burns (VMBS 2015).

Animal therapists note that people should avoid walking dogs on hot pavement or beaches, as pads on paws are sensitive and can burn easily (Early 1989). Factors influencing the extent of burning in mammals include applied temperature, achieved temperature in tissue, ability to conduct excess heat away, duration of exposure, and thermal capacity of tissue (Wohlsein et al. 2016). In warm to hot conditions, pavement tolerable to human skin can potentially harm dogs. Animals lack the rich superficial vascular plexus of humans, resulting in less efficient heat dissemination and comparatively higher vulnerability to heat exposure (Wohlsein et al. 2016).

A harmful experience for the dog might not be evident to the casual owner when walking. Often, dogs don't express discomfort when enthusiastically exercising (Bender 2019). Thus, humans should closely monitor their dogs—not only skin condition, but also breathing pattern and other indicators—when exercising their dogs in marginal or extreme environments. For example, a widened tongue and heavy panting indicate the dog is working hard to maximize air circulation to try to stay cool (Forgues 2012). At warmer air temperatures, the panting mechanism necessary to stay cool cannot function effectively. Dogs warm considerably as outside air temperatures reach 80 oF,

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Paul F. Hudak

while unfit dogs may be stressed at much lower temperatures (Foley 2015). High humidity levels compromise the evaporative cooling mechanism, thus worsening overheating tendencies in dogs (Bruchim et al. 2006).

While warm to hot outside temperatures are known to be harmful, additional research documenting temperatures of ground surfaces encountered by dogs can add context to the problem. The objective of this study was to measure and evaluate temperatures of different ground surfaces in two settings: (1) a built environment (street) in a suburban neighborhood; and (2) a nature trail along the edge of a lake.

MATERIALS AND METHODS

Case 1 – Built Environment

Ground temperatures were measured along a street commonly used for walking dogs in a suburban neighborhood located approximately 35 miles (48 kilometers) north of Dallas, Texas (Figure 1). Long, hot summers and short, mild winters are typical of the study area. A CN8550AT infrared thermometer (Thermatest of Ohio, Avon, Ohio) with a 12:1 distance-to-spot ratio was used to measure temperatures at 30 sites on four occasions: 8:00 a.m. (Survey 1) and 4:00 p.m. (Survey 2) on June 5, 2020; and 8:00 a.m. (Survey 3) and 4:00 p.m. (Survey 4) on August 10, 2020. Air temperature and relative humidity were also measured at the beginning and end of each survey. Each measurement site featured four common ground materials at the corner of a concrete driveway (Figure 2). The corner opposite the mailbox was used to avoid possible shading effects. Ground materials were concrete in the driveway, grass in the bar ditch, chip seal in the road, and tar patch in the road. Chip seal is an application of asphalt binder covered with a layer of compacted aggregate (TDOT 2017). Temperature measurements were tabulated, and statistics were used to describe the data and evaluate differences between ground material, time of day, and date of survey.

Case 2 – Nature Trail

In Case 2, using the same thermometer, temperatures of 10 different earthen surfaces were measured along a nature trail (Figures 1 and 3). Measurements were taken in seven surveys, starting at two-hour intervals from 8:00 a.m. to 8:00 p.m., on August 30, 2020. The area was partly cloudy in the morning and sunny in the afternoon. The first measurement was taken shortly after sunrise, and the last measurement was made at dusk. Rain fell in the early morning hours preceding the first set of measurements, but not later in the day.

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Paul F. Hudak

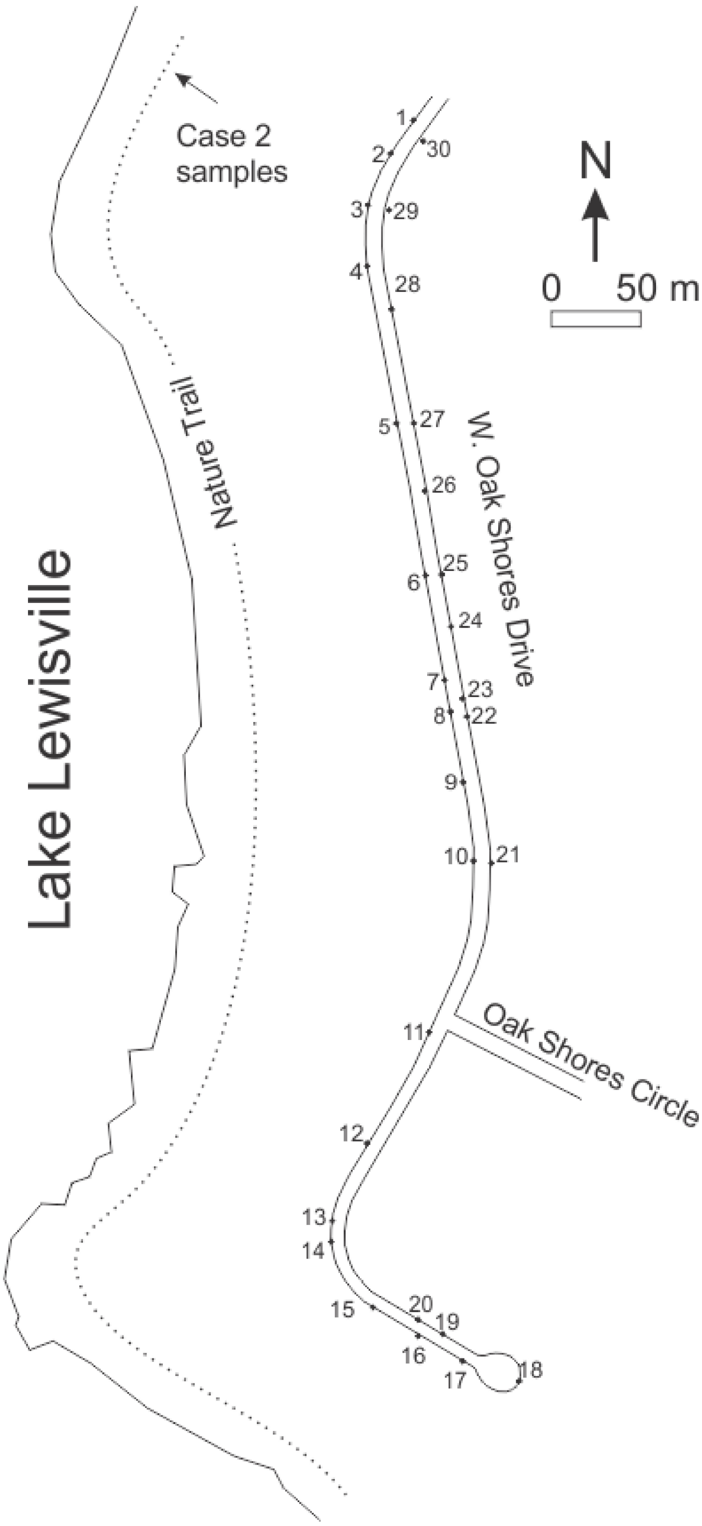

Figure. 1. Map of walking path (Case 1) and nature trail (Case 2).

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Pet Behaviour Science
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Paul F. Hudak

Figure 2. Four cover types, Site 12 (Case 1).

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Paul F. Hudak

Figure 3. Measurement sites (up to down along columns): water, moist brown sand, gray cobbles, brown sand, beige rock, brown rock, green grass, light brown sand, beige mudstone, and multicolored sand and pebbles (Case 2).

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Pet Behaviour Science
2022, Vol. 12, 31 - 42
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Paul F. Hudak

RESULTS AND DISCUSSION

Case 1 – Built Environment

Each survey took approximately one hour to complete. Skies were partly cloudy, with calm southerly winds and no rain on each survey date. Air temperature was 78.0 ºF (25.6 ºC) and 81.9 ºF (27.7 ºC) at the beginning and end, respectively, of Survey 1; 94.8 ºF (34.9 ºC) and 95.0 ºF (35 ºC) for Survey 2; 81.9 ºF (27.7 ºC) and 82.8 ºF (28.2 ºC) for Survey 3; and 96.1 ºF (35.6 ºC) and 97.0 ºF (36.1 ºF) for Survey 4. Relative humidity was 74% for Survey 1,47 % for Survey 2,76 % for Survey 3, and 39 % for Survey 4. Soil was moist for Surveys 1 and 2 from rain in the preceding early morning hours and dry for Surveys 3 and 4. Tree canopies shaded most samples in the 8:00 a.m. surveys, but very few samples in the 4:00 p.m. surveys (Tables 1 and 2).

Median ground temperature ranged from 81.2 ºF (27.3 ºC) for grass at 8:00 a.m. on June 5, 2020 to 140.3 ºF (60.2 ºC) for tar at 4:00 p.m. on the same date (Tables 1 and 2). Surface temperatures varied with material, time of day, and (to a lesser extent) date. In each survey, median temperature was highest for tar, followed by concrete seal, concrete, and grass; these differences were statistically significant (Kruskal-Wallis p-value < 0.00001).

Materials with lower specific heat capacity, such as tar and asphalt binder in chip seal, warm more quickly with incoming solar energy, thereby reaching higher temperatures, especially later in the day. Organic matter such as grass has lower specific heat capacity than mineral matter in soil (Kodesova et al. 2013) and many constructed surfaces, which helps moderate warming with added heat during the day.

For each material, afternoon temperatures were significantly higher than morning temperatures on each survey date. A paired Mann-Whitey U test produced *p-values* less than 0.00001 for each ground material when comparing morning to afternoon temperatures on each survey date. Furthermore, for each material, temperatures measured on August 10, 2020 were higher than those measured at the same time of day on June 5, 2020, except for tar in the afternoon. However, significant differences were only observed for concrete and chip seal in the morning. A paired Mann-Whitney U test produced *p-values* of 0.00006, 0.0278, 0.0001, and 0.06148 for concrete, grass, chip seal, and tar, respectively, between the two mornings; and 0.28462, 0.1074, 0.86502, and 0.47152 for concrete, grass, chip seal, and tar, respectively, between the two afternoons. Thus, date had much less effect than time of day on surface temperature.

Case 2 – Nature Trail

Air temperatures were slightly lower in Case 2 than in Case 1, ranging from 74.7 ºF (23.7 ºC) at 8:00 a.m. to 92.5 ºF (33.6 ºC) at 6:00 p.m. (Figure 4). Relative humidity dropped throughout the day, reaching a high of 100% at 8:00 a.m. and a low of 58% at 6:00 p.m.

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Pet Behaviour Science
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Paul F. Hudak

Temperatures varied considerably with ground material and time of day. Overall, ground temperatures ranged from 76.4 ºF (24.7 ºC) at gray (water-stained) cobbles (alluvium) and beige rock (marl) at 8:00 a.m. to 125.7 ºF (52.1 ºC) at brown sand (alluvium) at 4:00 p.m. (Figure 4). Other materials with relatively high temperatures were multicolored sand and pebbles, and brown rock (iron oxide-bearing sandstone), whereas water and moist sand maintained relatively low temperatures throughout the day (Figure 4).

Darker-colored material, such as fragments of iron oxide-bearing sandstone, tend to absorb more heat and reach higher temperatures than lighter-colored material. Water and moist ground have relatively high specific heat capacity, thus moderating temperatures for those materials throughout the day. Additionally, evaporation from moist surfaces and transpiration from grass takes up heat and has a local cooling effect (Alexander 2011).

Site Number	Survey 1 Morning, June 5				Survey 2 Afternoon, June 5			
	C	G	S	T	C	G	S	T
1R	81.1*	80.6*	85.1*	86.9*	134.7	114.2	137.6	151.1
2L	87.4	86.5	88.5	93.5	131.0	111.9	135.6	150.0
3L	82.9*	79.8*	83.6*	92.8*	132.9	102.0	138.3	148.6
4L	82.2*	80.2*	84.0*	86.5*	131.9	111.7	127.0	144.6
5L	78.8*	78.6*	82.7*	85.8*	134.2	103.4	129.7	144.3
6L	81.3*	80.6*	84.2*	87.4*	127.4	104.7	131.1	145.4
7R	81.3	81.6	83.4	87.0	124.7	107.2	130.1	144.5
8R	84.7	82.7	86.5	93.0	124.1	101.4	125.2	143.6
9L	85.2	83.8	87.4	93.5	123.4	101.8	128.1	140.1
10R	81.8*	79.8*	83.4*	87.6*	127.7	104.7	127.4	145.2
11R	88.5	87.4	91.7	95.1	129.0	111.9	138.2	147.3
12R	82.4*	81.1*	85.4*	87.9*	127.5	107.6	142.1	148.6
13R	83.1*	81.5*	84.9*	87.8*	131.1	111.9	133.7	142.8
14R	82.2	82.5	83.3	84.0	127.7	116.2	131.5	138.9
15R	85.6	88.1	87.6	90.1	100.5*	89.9*	101.3*	140.0
16R	78.0*	79.5*	81.3*	83.4*	95.3*	88.3*	101.4*	107.7*
17R	85.2	82.5	87.4	88.8	102.9*	91.9*	104.9*	143.2
18R	81.1*	81.3*	81.6*	83.1*	109.2*	90.3*	119.3*	123.4*
19L	81.5*	78.6*	81.5*	84.9*	121.2	96.8	125.2	140.5
20R	80.4*	77.7*	80.7*	82.9*	122.1	98.2	121.8	110.1*
21L	82.4*	80.4*	82.9*	86.5*	127.7	108.3	127.5	141.8
22R	80.9*	79.8*	83.8*	87.0*	117.8	104.3	125.7	138.5
23L	82.9*	81.3*	83.3*	87.2*	123.4	109.4	124.8	130.2
24L	87.4	87.2	87.6	94.2	124.5	106.1	124.8	130.6
25L	82.9*	80.7*	81.8*	84.5*	119.3	102.2	122.0	133.7
26R	87.0	86.9	87.0	95.5	120.0	96.6	122.0	133.3
27R	80.2*	79.3*	79.1*	83.1*	117.3	98.7	115.7	126.6
28L	80.2*	80.0*	83.3*	87.2*	119.4	102.3	123.8	133.5
29R	87.9	88.3	91.2	96.9	123.4	102.3	136.0	138.9
30L	82.2*	82.0*	83.1*	87.6*	120.0	102.0	126.6	137.3
Median	**82.3**	**81.2**	**83.7**	**87.3**	**123.8**	**102.9**	**126.8**	**140.3**

°C=5(°F-32)/9

* Shaded by tree canopy

Table 1. Temperature Measurements (oF) for Concrete (C), Grass (G), Chip Seal (S), and Tar (T) in Surveys 1 and 2 (Case 1)

Pet Behaviour Science open access journal

Pet Behaviour Science
2022, Vol. 12, 31 - 42
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Paul F. Hudak

Site Number	Survey 3 Morning, August 10				Survey 4 Afternoon, August 10			
	C	G	S	T	C	G	S	T
1R	85.8*	84.5*	87.8*	91.0*	132.4	134.4	137.1	150.0
2L	89.2	84.5	91.5	92.8	130.1	115.8	136.2	148.1
3L	84.9*	80.2*	85.2*	91.5*	129.5	102.5	137.6	145.2
4L	84.3*	82.5*	87.9*	89.0*	132.2	129.2	127.4	139.8
5L	85.5*	82.7*	87.0*	87.9*	137.3	128.4	128.1	143.6
6L	85.8*	82.5*	87.6*	89.6*	128.6	110.6	131.5	143.4
7R	84.3*	81.5*	87.9*	89.2*	125.0	107.9	130.6	142.8
8R	87.6	83.3	88.8	91.9	127.0	100.0	124.3	143.7
9L	84.0	80.7	85.1	91.7	119.8	97.1	126.3	140.1
10R	85.4*	82.0*	86.1*	88.5*	128.4	100.2	126.6	144.5
11R	89.7	85.2	90.6	93.9	130.1	119.1	142.1	146.3
12R	87.0*	81.3*	88.7*	90.3*	130.1	100.9	141.4	145.7
13R	87.0*	81.6*	88.3*	89.4*	132.4	106.8	133.7	149.3
14R	86.7*	82.9*	88.1*	88.5*	130.2	119.6	136.2	138.2
15R	88.7	89.4	88.7	90.3	100.5*	91.4*	101.1*	124.8*
16R	82.5*	81.5*	84.3*	84.5*	99.1*	91.5*	101.3*	106.7*
17R	84.9*	81.8*	86.3*	87.6*	105.2*	95.0*	108.1*	112.1*
18R	84.9*	79.8*	86.0*	86.1*	108.6*	90.3*	113.7*	115.7*
19L	86.0*	82.9*	84.9*	87.6*	124.5	105.4	123.6	134.6
20R	85.4*	80.2*	85.4*	85.2*	122.9	98.2	117.1	107.6*
21L	84.3*	81.3*	86.9*	88.8*	129.5	127.4	132.2	143.6
22R	83.8*	81.8*	86.1*	88.3*	121.2	117.5	127.5	137.4
23L	86.5*	86.3*	87.2*	89.0*	125.9	124.3	127.5	136.4
24L	86.5*	85.1*	87.0*	88.1*	125.6	109.9	124.5	130.1
25L	85.1*	82.0*	87.0*	87.0*	125.9	102.0	120.5	135.6
26R	89.0	87.0	91.0	95.5	121.8	101.3	125.4	137.0
27R	81.8*	81.8*	83.6*	85.8*	123.2	113.0	119.3	129.5
28L	85.2*	83.6*	86.1*	88.3*	125.7	109.4	127.0	134.0
29R	88.5	87.0	89.6	96.4	124.7	105.6	130.2	138.5
30L	86.3*	82.2*	87.8*	88.3*	126.1	112.6	126.8	137.3
Median	**85.7**	**82.4**	**87.1**	**88.9**	**125.9**	**107.4**	**127.2**	**138.4**

[#] °C=5(°F-32)/9

* Shaded by tree canopy

Table 2. Temperature Measurements (oF) for Concrete (C), Grass (G), Chip Seal (S), and Tar (T) in Surveys 3 and 4 (Case 1)

Earliest temperature measurements were lowest for all materials. Ground surfaces accumulated heat during the day and reached highest temperatures in mid to late afternoon. Temperature variations between different ground surfaces were most pronounced in mid-afternoon. All ground surfaces showed much greater range in temperature than air (Figure 4).

CONCLUSION

Outside air was warm, up to 97.0 oF (36.1 oC), but not excessively hot, during the temperature surveys. However, ground temperatures reached hazardous levels in both built and natural settings. Dry, non-vegetated, dark surfaces reached the highest temperatures, up to 151.1oF (66.2 oC) in the built environment. Such high temperatures are potentially dangerous to dogs.

Pet Behaviour Science open access journal

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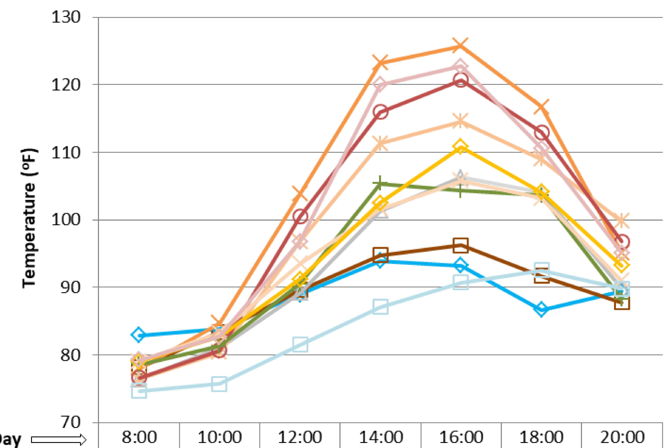
Paul F. Hudak

Mammalian skin cannot tolerate lengthy exposure to temperatures above 111 oF (44 oC) (Wohlsein et al. 2016). Additionally, hot surfaces along walking paths compound health risks associated with high air temperatures and humidity levels.

This study adds quantitative context to our understanding of heat encountered by dog paws in different walking environments. The study was limited to two walking paths in north-central Texas. Additional studies, including different surface materials and environments, could add further to our understanding of ground-related heat hazards for dogs. Additional studies should also consider breed differences and habituation, both critical factors affecting environmental hazard for dogs.

Walkers should avoid inflicting possible harm to dogs by closely monitoring them, avoiding hot surfaces during warm conditions, and avoiding hot weather altogether. On warm days, other coping strategies include walking over moist earth or through shallow water, using protective paws pads, and finding shade when available.



Time of Day	8:00	10:00	12:00	14:00	16:00	18:00	20:00
Water	82.9	83.8	89	93.9	93.2	86.7	89.4
Moist Brown Sand	78.2	83.4	89.6	94.8	96.2	91.7	87.8
Gray Cobbles	76.4	81.1	89.2	101.3	106.3	104.1	89.9
Brown Sand	78	84.7	103.8	123.2	125.7	116.7	95.1
Beige Rock	76.4	80.4	96.8	111.3	114.6	109	99.8
Brown Rock	76.6	80.7	100.5	116	120.7	113	96.8
Green Grass	78.6	81.3	90.5	105.4	104.3	103.6	88.3
Light Brown Sand	79.1	83.3	93.5	101.6	105.8	103.2	91
Beige Mudstone	79.1	82.7	91.2	102.5	110.8	104.1	93.2
Multicolored Sand and Pebbles	79.3	82.7	96.8	120	122.7	110.6	95.1
Air	74.7	75.7	81.5	87.1	90.7	92.5	89.8

Figure 4. Plots of air, water, and ground surface temperatures against time (Case 2); oC=5(oF-32)/9

Pet Behaviour Science open access journal
Pet Behaviour Science
2022, Vol. 12, 31 - 42
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Paul F. Hudak

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Pet Behaviour Science open access journal

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