Temperature Effect on Captive Asian Elephants in Arid Regions of North India

A Review of Adaptations; Potential Health Consequences from Poor Thermoregulation

Surendra Varma, S. R. Sujata and David Abraham

Elephants in Captivity: CUPA/ANCF- Occasional Report.5

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Preface

The occurrence of elephants in regions where ambient temperatures are in the range of 36-42°C can be detrimental to the animals. An understanding of the relationship between temperature and welfare conditions of these elephants becomes extremely vital. Arid regions of India do not support any wild elephants; however captive elephants have found their way in these regions through mostly illegal means. The presence of approximately 150 elephants in the arid regions of north India has been reported.

Keeping elephants in arid regions, particularly in cities of Jaipur and Ahmedabad, has been severely criticized. In addition to the existing unsuitable and unnatural conditions, an important criticism has to do with the region going through intense heat and observed sufferings of elephants (using their trunk to suck secretion and spraying this on themselves). However, there is an argument that elephants (of different species) are known to be found in desert regions and this has been used as a justification for keeping Asian elephants in arid regions. There has been no attempt to review the influence of extreme weather on the presence of elephants in these arid regions.

This document is a first attempt in this direction. We explore the knowledge of fluctuating ambient temperatures (different seasons with extremes of temperature) for the cities of Jaipur and Ahmedabad as examples of arid regions, relating this with relatively non-varying body temperature of elephants. We compare the ambient temperature of natural (forests) and unnatural (cities) habitats across the country which includes the above mentioned cities.

In an attempt to know elephant adaptability to desert/arid conditions, we have tried to review the morphological, behavioural adaptations/constraints of the living elephant species of the world. It is assumed this report would provide a basic knowledge about temperature, its effect on elephants and the tolerance level. The prevalent lack of knowledge or the assumptions of temperature tolerance, along with the commercial and traditional interests of keeping elephants, could be responsible for the continued existence of elephants in this region. It is also assumed that this knowledge would act as a first step in helping the elephants kept in their present locations in arid areas.

Acknowledgements

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Special thanks are due to the Gujarat Society for Prevention of Cruelty to Animals (GSPCA) team, more specifically Ms. Snehal Bhatt for providing information on the current welfare status of elephants in Gujarat State and Mr. Raj Bhavsar, provided photographs of the ground status of elephants in this region. Dr. Sunil Chawla of Help in Suffering (HIS) introduced one of our investigators (SV) to the elephant owners, mahouts and others associated with elephant keeping in Jaipur. Direct observation on elephants, mahouts and visit to different locations of Jaipur City provided insights on elephant status in the location.

Dr. Heidi Riddle of IUCN/SSC Asian Elephant Specialist Group (AsESG), Dr. N. M Weissenbock, of Vienna Zoo, Austria and Dr. Roshan K Vijendravarma, Post Doctoral Researcher, Department of Ecology and Evolution, University of Lausanne, Switzerland read through the earlier version of the document and provided very useful suggestion and their suggestions and inputs improved the quality of the document. Dr. Shiela Rao and Suparna Ganguly of Compassion Unlimited Plus Action (CUPA) provided critical inputs. Sreenivasa Rao and Susanto Sen provided editorial support.

Introduction

The Asian elephant (*Elephas maximus*) occurs in its natural, free ranging, and wild state in several regions of India (Sukumar and Santiapillai, 1996). The occurrence of these in animals in the wild has not been reported arid/ semi-arid areas. The only elephants occurring in such regions are captive animals. Under natural conditions all natural processes, including temperature variation, is taken care of through ecological and behavioural mechanisms. In unnatural conditions, such as those experienced in captivity, along with variation in behavioural and ecological factors, tolerance to extreme temperatures is always a challenge for the animal. In India, arid/ semi-arid regions such as Jaipur/ Ahmedabad experience extremes of temperature variation (ranging from 40-10°C) across seasons. This ambient temperature could prove detrimental to elephant health considering their biology, thermoregulatory mechanisms and restrictions imposed by captive work conditions/ living environment.

Elephants maintain a body temperature around 35.9 °C (Shoshani and Eisenberg, 1982), a variation of around one degree (35-36.5°C) observed in their urine temperatures (Benedict and Lee, 1936), their skin is nearly furless, a surface which allows for heat exchange with the surroundings. Heat is generated / lost from the animal depending on the ambient temperature, to maintain an isothermal body temperature (Narasimhan, 2008). Use of their ears as "thermal windows" is said to a mechanism of heat exchange in elephants (Kinahan, et al., 2007). Weissenbock (2006) cites more ways of thermo-regulation in elephants: vasodilatation of the pinnae, hydration of the skin and by behavioural means through contextual use of shade, wind, water and dust. Under conditions of high surrounding temperatures, elephants maintain their body temperatures by resting in shaded areas (Kurt and Garai, 2007) and/ or flapping their ears (Kinahan et al., 2007).

Under unnatural conditions the strain imposed on an animal, from prolonged exposure to extreme temperature variation, may result in reduced health and welfare status. Large body size of these animals implies slow temperature exchange with the surroundings. This is because the ratio of volume to surface area is high, with the most unfavourable surface-area to volume ratio observed for elephants among all terrestrial mammals (Weissenbock, 2006), meaning greater body mass as compared to the area of the skin covering the mass. Thus, heat exchange is slow. This could be avoided to a certain extent by greater conductance of the skin (cited by Kinahan, et al., 2007). Even if thermal conductance is efficient, captive conditions expose the animals to durations of extreme temperature without recourse to natural behavioural expression of maintaining normal body temperatures: wild elephants choose suitable landscape to facilitate heat exchange (Kinahan, et al., 2007), a feature conspicuously absent either due to the practice of chaining or due to their work schedule.

The biological mechanisms available in elephants to tolerate extreme temperatures, and the implications on welfare and health from prolonged exposure to extreme air temperatures for Asian elephants in captivity, more specifically in arid regions of Northern India, are reviewed here.

A related aspect is the occurrence of African elephants in desert regions (say, Namib Desert) being used as an example of the animal's ability to adapt to arid conditions, and as justification for keeping captive elephants in such regions. Demonstrating the biological features of the living species of elephants of the world and their differential temperature adaptation mechanism becomes very essential. In addition, a comparison of the mean body temperature of Asian elephants and the ambient temperature experienced in their natural habitat as well as in urban areas in India may provide some insight into the altered temperature conditions experienced in captivity.

This review focuses on the temperature effect on captive Asian elephants in arid regions of north India in the following manner:

- Initially we examine the knowledge available on the Asian elephant body temperature and compare it with winter and summer minimum and maximum of two cites of arid regions of north India, where captive elephants have been used for traditional and commercial interests.
- We compare biological or behavioural adaptations of the living species to demonstrate unfavorable biological mechanism Asian Elephants have with respect to desert or arid regions.
- We further use existing knowledge on elephant body and ambient temperatures for natural forests and the unnatural environment, in which Asian elephants have been reported, to compare the pattern of differences in body and ambient temperatures.
- We list the constraints imposed on elephants by captivity in their attempts to cope with extreme temperature variation.
- The effect of extreme heat or cold on elephant health is also reviewed.

Captive elephants in Arid regions of north India

Population status and management

For this review, two locations Jaipur (75.80° E, 26.90° N) and Ahmedabad (75.56° E, 23.03° N) located in Rajasthan and Gujarat States of northern India, respectively, were considered. Jaipur has 119 captive elephants of which 112 are females and 7 are adult males. In the past, historically, they have been used for hunting, processions and war; currently they are used to entertain tourists (Figures 1, 2, 3a and b, 4 and 5). Apart from the exposure of extreme temperatures, the elephants in Jaipur are known to suffer from improper management and husbandry practices such as unsuitable living conditions (Figure 6a, b, 7a, b), inadequate provision of water, frequent translocation across locations, etc., and the keepers lack basic knowledge of elephant care and continue to practice harmful and painful treatment patterns (Madhulal, 2008).

Figure 1: Work type; carrying tourists in very sunny hours

Figure 2: Work type; displayed on road side with little or no shade – as tourist attraction

Figure 3a: Walking on a tarred road during the peak sunny hours

Figure 3b: Walking on a tarred road and heavy vehicular traffic during the peak sunny hours

Figure 4: Mother and calf displayed during a sunny day - as tourist attraction, note a visitor taking photo guided by elephant owner

Figure 5: Closed shelter, with very little or no ventilation

Ahmedabad has 21 elephants (16 adult females, five adult males). These elephants are used for begging/blessing activities, in marriage functions and religious processions. They travel all over Gujarat to places which hire them, frequent the city of Ahmedabad (figure 8a, b) to provide rides for people and children around a big lake. The maximum distance covered, carrying any load for work, was 20 to 60kms, at times 300kms across four days (Varma et al., 2008).

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Figure 6a: Open shelter, close to an industrial area, no vegetative cover, body and legs are tied

Figure 6b: Shelter type single tree cover, legs tied

Figure 7a: Source of shade, canvas tent, legs tied limited scope of movement

Figure 7b: Source of shade: Elephants are made to stand under partial vegetative cover

Mean temperatures

Arid regions experience wide variation in terms of extremes in temperatures. Minimum summer temperature for two cities (Jaipur and Ahmedabad) is 25.8˚C and 25 ˚C respectively. Summer maximum for both cities is reported to be 45 ˚C. Minimum winter temperature for these cities is 5˚C and 15 ˚C respectively while the maximum winter temperature is reported to be 22˚C and 35 ˚C.

Comparison of elephant body and mean air temperatures for two cities in arid region of India

The hottest months of summer in Jaipur and Ahmedabad showed maximum temperatures of 45 ˚C. This implies an experience of approximately 9 ˚C deviation from the elephant's normal body temperature (Figure 9a and b). Thus, on an average, the elephant experiences an increase of 9˚C for those days when temperature is 45 ˚C in these two cities. Coupled with this, the average rainfall during this period is low. Physical exertion, for these working animals, adds to the generation of body heat. Thus, maintenance of body temperatures becomes a major issue

Figure 8a: Work type, waiting for the customer to arrive for a jolly ride

Figure 8b: Work type, waiting near a mall for potential customers

of health and consequent welfare for elephants as heat loss from its body is slow (Weissenbock, 2006). Also, the animals' movement is controlled by its handlers, thereby restricting the choice available to the animals in opting for a suitable area.

Minimum temperature during winter can be as low as 5˚C for Jaipur and 11˚C for Ahmedabad, data on the effect of low temperature on the welfare of Asian Elephants kept in arid or any other regions of India is lacking. However, the AZA (Annon., 2003) recommends maintenance of a temperature of at least 12.8 ˚C in its indoor holding areas for elephants. If we follow the same rate for arid region, this reflects a deviation of 7.8 ˚C (12.8 - 5˚C) with respect to the recommended ambient temperature for Jaipur and 1.8˚C (12.8-11˚C) for Ahmedabad. Acceptable deviation in the lower range can be up to 21˚C (35.9˚C – 12.8˚C). However, when the minimum is considered for these two cities the deviation from the body temperature of the elephant reaches up to 30.9˚C for Jaipur and 24.9˚C for Ahmedabad. This difference may be beyond the acceptable standard (of AZA) for elephants.

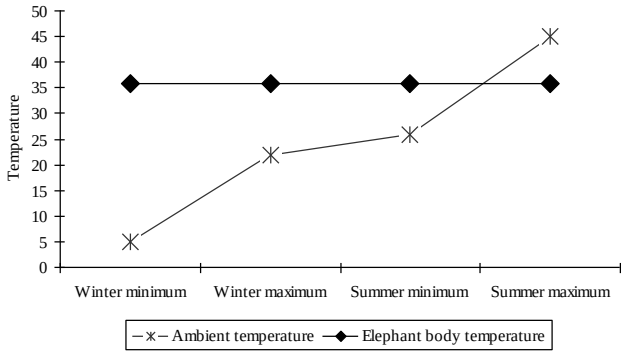


Figure 9a: Comparison of elephant body and ambient temperature of different seasons for Jaipur. Mean body temperature of elephant was plotted against the winter and summer extreme ambient temperatures.

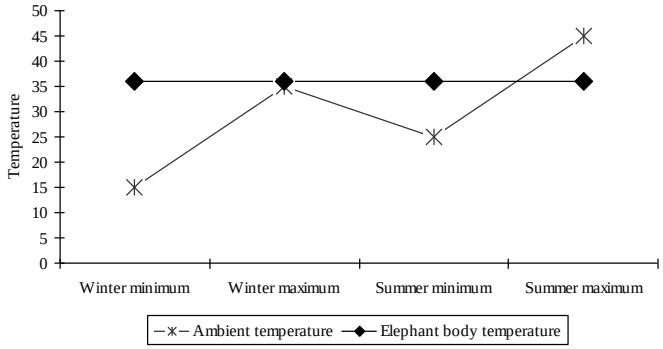


Figure 9b: Comparison of elephant body and ambient temperature of different seasons for Ahmedabad. Mean body temperature of elephant was plotted against the winter and summer extreme ambient temperatures.

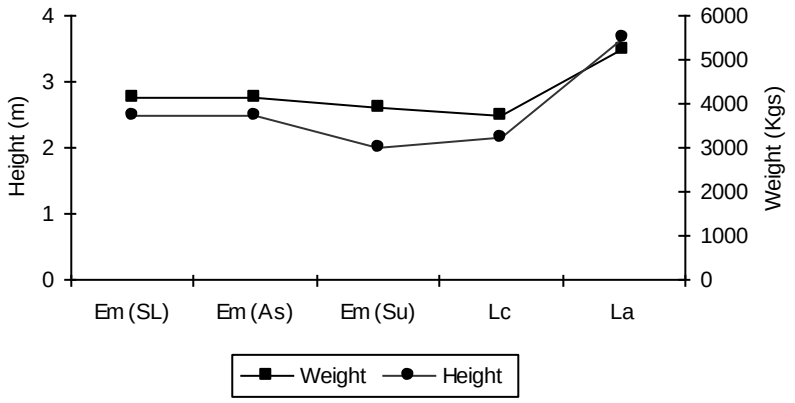
Insights on adaptations for withstanding extreme temperatures

The capacity to adapt to a given environment may vary from species to species and the occurrence of African elephant in desert region, more specifically the Namib Desert could be specific to the biological and behavioural adaptation that this species has developed over a period of time. The adaptations crucial to survival under arid conditions could be based on many factors and understanding of the some of the features may provide some insights on this aspect. Among many factors a few, where some knowledge is available, is presented below.

Allometry and reduced body temperature

Allometric scaling proposes known scaling rate between body mass and metabolic rates (Chaui-Berlinck et al., 2005). For instance, the rate of heart beat for mice is around 500/ minute, for people 70/ minute and for elephants, it is 28/ minute. Thus, body mass is said to exhibit certain scaling rates with body temperature. Hence, increase in body mass may involve reduced body temperatures.

For some understanding of this aspect, body weight and height of the three species of elephants of Loxodonta *Africana, Loxodonta cylotis* and *Elephas maximus* is considered. Of these, the largest land mammal is the African savannah elephant (Figure 10)



Em (SL): Elephas maximus Sri Lanka Em (As): Elephas maximus Asia mainland
Em (Su): Elephas maximus Sumatra Lc: Loxodonta cyclotis
La: Loxodonta Africana

Figure 10: Comparison in dimensions of elephant species: Mean body weight and height was plotted against different species of elephants

Forest dwelling elephants such as the African forest species (*Loxodonta cyclotis*) and the Asian elephant (*Elephas maximus*) are smaller than their African savannah counterparts. However, despite size difference, body temperatures of Asian and African species are comparable: 35.9 ^{o} C for Asian elephants (Shoshani and Eisenberg, 1982), 36.1 – 36.7 ^{o}C for African elephants (Buss and Wallner, 1965).

Thus, based on mean body temperatures only, the African savannah elephant and the Asian elephant show no difference in their ability to withstand high air temperatures such as those experienced in the Namib Desert. However, adaptations of the animal's morphology may be unique to their living environment.

Color

Temperature control through skin pigmentation was hypothesized to play a role in maintaining body temperature (Hamilton and Heppner, 1967)[†]. Heppner (1970) cites several studies which demonstrate more absorption of solar radiation among black colored animals. Among elephants, skin color of the African species is lighter brownish-gray, while the Asian species is blackish-gray in color, thus, predisposing the animal to a difference in the quantity of incident radiation reflected/ absorbed. Apart from colour, skin texture may be involved in thermoregulation for which detailed investigations need to be carried out.

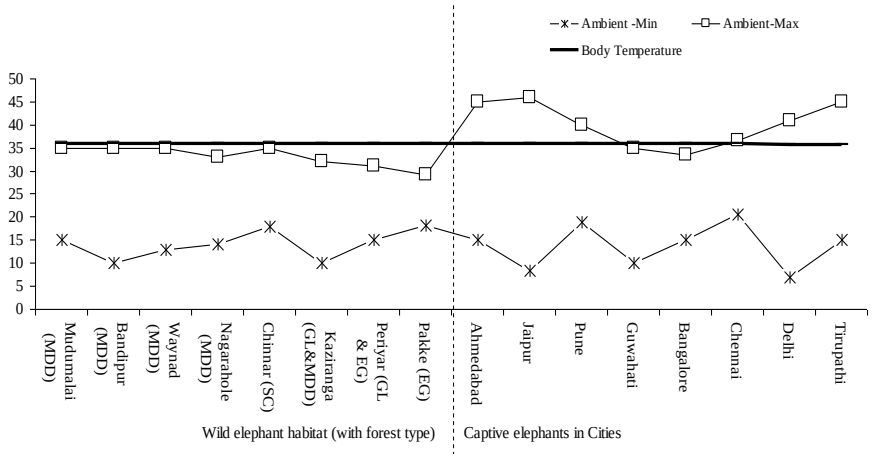
Ear size

African elephants have larger ear flaps as compared to the Asian species. A study by Phillips and Heath, (1992)[†] reports greater loss of heat (around 90% of the standard metabolic rate) in *Loxodonta africana* than in *Elephas maximas* (33 % of the standard metabolic rate) assuming certain wind speed and temperature gradient. The rate of heat loss in the Phillips and Heath study refers to temperate regions, and the rate maybe different in tropical regions which maybe poorly investigated. However, it should be noted that the rate of heat loss for these two species is likely to be different, depending of the locations and the tropical or temperate regimes in which they are exposed to.

Scaling alone indicates no difference in adaptability between African savannah and Asian elephants in relation to body temperature. When skin colour and ear-size are considered, African savannah elephants seem to have better adapted to arid regions then their Asian counterparts. The morphological differences in their body size, ear surface area (Narsimhan, 2007) and skin coloration indicate that Asian elephants are suited to forested regions. The occurrence of African elephants in the Namib Desert does not imply that their Asian counterparts will be able to withstand the same arid conditions and keeping Asian elephants in cities may not be justifiable. This can be seen from the comparison of the differences in ambient temperatures of some of natural (forests) and unnatural (human dominated and influenced) habitats with body temperature of Asian elephants.

Variation in ambient temperature across forest habitat and cities

Comparison of temperatures across different wild elephant habitats, cities (where captive elephants are kept) in India, and mean body temperature of elephants is presented in Figure 11. It provides very distinct patterns for cities where elephants are kept. The maximum ambient temperature is below the mean body temperature in wild elephant habitats and minimum ambient temperature falls within the prescribed limit (American Zoo and Aquarium Association (AZA) standards). The pattern for cities with captive elephants shows increase in ambient temperature above the mean body temperature and minimum ambient temperature below the prescribed limit.



MDD; Moist deciduous, SC; Scrub, GL: Grassland, EG: Evergreen

Figure 11: Comparison of ambient minimum, maximum temperatures for different wild elephant habitats and cities and body temperature of elephant

Considering temperature as a reference, cities (captive elephant locations) and deserts (with greater temperature variance) may be unsuitable habitat, specifically for Asian elephants

Impediments to normal thermoregulation in captivity

Slow loss of body heat makes elephants more tolerant to low temperatures (4^{o}C or less), but protection from winds needs to be ensured (BIAZA, 2006). As a consequence of high surface to volume ratio for the ear region ([†]Benedict, 1936), greater loss of body heat may occur during low air temperatures. Ear skin temperature of elephants, is reported to show a steep reduction on exposure to low air temperatures, such as during winter or early in the morning, as a way of minimizing heat loss by vaso-constriction (Weissenbock, 2006). Thus, reduction of ear skin temperature can be expected on a consistent basis during winter months. Drop in skin temperatures below freezing point in the ear region is considered a health hazard (Weissenbock,

2006). Rees (2004) reported increased incidence of stereotypy among captive adult Asian elephants in a zoo under conditions of low ambient temperature (9 ^{o}C) with hunger and inability to reach its shelter being considered possible proximate causes for such stereotypy. However, young calves (male/female) and one adult male did not show stereotypy in the study. Smaller elephants with lower body mass showed negative correlation with frequency of stereotypy as compared to elephants with larger body mass. The authors opine stereotypy to be associated with greater loss of heat for smaller elephants.

Captive elephants in the cities of Jaipur/Ahmedabad are kept outside in places where tourists visit, either to be used for begging or providing rides. Such places do not have access to temperature control, thus exposing the animals to the twin dangers of low temperatures and prevailing wind.

Wild elephants have been reported to rest under the shade of trees during the hottest parts of a day (Kurt and Garai, 2007). Adaptation through behavioural means to changes in temperature, observed in wild animals, is restricted among most captive elephants due to the practice of chaining the animals and/ or absence of suitable environmental features in captivity. Consequently performance of species-specific behaviours such as dust-bath/ wallow is prevented during periods of high ambient temperature. Such behaviours otherwise aid in thermoregulation (Shoshani and Eisenberg, 1982).

Captive elephants, with restricted movement due to chaining/ confined space, cannot choose where to stand (in any available shade) or move at will in order to maintain their body temperature during hot weather. Added to this is the physical exertion of performing for the public, either for tourist rides or as a part of processions. These activities increase body temperature without recourse to lowering it by seeking rest or shade, as movement is controlled by the handlers.

As size increases, surface area to volume ratio reduces (Kinahan, et, al., 2007). This forms an important factor for thermo-regulation in mammals dependent on loss / gain of heat from their surface— placing importance on the exposed, furless skin of elephants to assist in maintaining body temperature. The practice of placing tourist-utility materials like the howdah on these elephants further exacerbates their inability to control body temperatures as such materials can prevent heat loss from the body during hot weather conditions.

Effect of extreme temperature on captive elephants in arid regions

Extremes of environmental temperature variations are harmful to mammals in the absence of adaptations to such conditions. Elephants are the largest terrestrial mammals and their body systems have unique anatomical and physiological peculiarities. The following points describe the inability of elephants to cope with extremes of environmental temperature. Unlike small mammals, elephants can adjust their body temperature only to a limited extent of few degrees more than the highest value suggested above. Extreme variation in ambient temperatures as experienced in arid regions can be lethal, in severe cases, due to the dual causes of thermal inertia of the elephants and imposition of restricted freedom of movement in captivity.

1. Using their trunk, elephants suck secretions from the pharynx and spray it over their body to reduce body heat. Skin hydration is reported to aid in heat loss (Weissenbock, 2006). This action of spraying pharyngeal secretions over its body is likely to be an indication of physical exhaustion and thermal overload in captive elephants, a behaviour commonly seen in captive elephants kept in arid regions and taken on hot city roads (Varma, per.obs).

2. Elephants' ears are organs for heat dissipation. Flapping frequency of elephants' ears are indicators of thermal load; elephants tend to flap their ears more frequently when they are made to work under urban conditions. Hence an 'overheated' elephant will need more time to cool its body than other mammals with sweat glands, given the restrictions imposed by captivity.

3. Elephants taken on roads in urban areas in hot weather experience increase in body temperature. In such situations the practice of giving water immediately without giving time for the body to cool, affects health. Sudden cooling of the elephant's body is not good for its health and makes it prone to digestive problems like impaction – blockage of digestive tract –a major cause of death among captive elephants. Fowler and Mikota (2006) report occurrence of colic in some elephants undergoing heat stress due to increased blood supply to the ears/ skin to aid in thermoregulation, with consequent reduction of blood supply to the viscera. Ferrier (1947) too writes about the association between sudden cooling following increased body temperature and occurrence of colic.

4. An elephant's foot is also not suited to walk consistently on any kind of hard surface (Benz, 2005). Unlike horses and bullocks they do not have hooves to prevent wearing away; the bottom portion of elephant's feet does not have any hard covering. Hence, an elephant when taken on bitumen tarred roads during hot part of the day suffers from heat related problems and foot problems and pain.

5. Exposure to high temperatures may be associated with partial or complete blindness among elephants (Krishnamurthy and Wemmer, 1995 citing Ferrier's work; Baruah, 1998). Along with high temperature, poor nutrition, constant beatings by handlers in the temple area, occurrence of dust draught and infections, have been reported to cause vision related problems in captive elephants (Kurt and Garai, 2007).

All these factors suggest that Asian elephants are least suited to be maintained in conditions of extreme temperatures as experienced in arid regions of Northern India.

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† Original not seen

Compassion Unlimited Plus Action (CUPA) is a non-profit public charitable trust registered in 1991 that works for the welfare of all animals. Since 1994, CUPA has worked in close collaboration with government departments and agencies on various projects. CUPA's mission is to protect animals from abuse and violence and do what may be required to alleviate their suffering at the hands of humans. CUPA does not differentiate among pet, stray or wild animals, since all of them require assistance and relief from cruelty, neglect and harm. The organisation's objective has been to design services and facilities which are employed fully in the realisation of these goals.

Wildlife Rescue & Rehabilitation Centre (WRRC) is a registered public charitable trust for the welfare of wild animals and birds that often find themselves trapped in an urban environment. The Trust is a sister concern of CUPA and both organisations complement each other in their services. WRRC was established as a separate Trust in 1999.

Asian Nature Conservation Foundation (ANCF) is a non-profit public charitable trust set up to meet the need for an informed decision-making framework to stem the rapidly declining natural landscape and biological diversity of India and other countries of tropical Asia. The Foundation undertakes activities independently and in coordination with governmental agencies, research institutions, conservation NGOs and individuals from India and abroad, in all matters relating to conservation of natural resources and biodiversity, endangered flora and fauna, wildlife habitats and environment including forests and wetlands. It participates and disseminates the procured information, knowledge and inferences in professional, academic and public fora.

World Society for Protection of Animals (WSPA) With consultative status at the United Nations and the Council of Europe, WSPA is the world's largest alliance of animal welfare societies, forming a network with 910 member organisations in 153 countries. WSPA brings together people and organisations throughout the world to challenge global animal welfare issues. It has 13 offices and thousands of supporters worldwide.

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The occurrence of elephants in the wild has not been reported for arid/ semi-arid areas. The only elephants occurring in such regions are captive animals. Under natural conditions all natural processes, including temperature variation, is taken care of through ecological and behavioural mechanisms. In unnatural conditions, such as those experienced in captivity, along with variation in behavioural and ecological factors, tolerance to extreme temperatures is always a challenge for the animal. The biological mechanisms available in elephants to tolerate extreme temperatures and the implications on welfare and health from prolonged exposure to extreme air temperatures for Asian elephants, more specifically in arid regions of Northern India, are reviewed in this document.

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