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EFFECT OF AMBIENT TEMPERATURE IN DIFFERENT SEASONS AND ROOFING MATERIAL ON EAR FLAPPING BY ASIAN ELEPHANTS IN CAPTIVITY - A STUDY FROM TAMIL NADU, INDIA

Vanitha V. and Baskaran N.

Introduction

Homeotherms have adapted to new or changing environments by varying the size and shape of their bodies and extremities (Phillips and Heath 1992). These physical changes facilitated heat conservation or dissipation as dictated by ambient conditions. Body temperature regulation appears to scale with body mass in vertebrates (McNab 1983). Larger animals need to develop means of dealing with great amount of heat that they produce (Phillips and Heath 1992). They cool slower than smaller ones and would appear to favor cold temperature, since surface area-to-volume ratio decreases with increasing body size and fur can be thicker on larger animals (Schmidt–Nielson 1984). On the contrary, among the large mammals that inhabit the tropical environment, elephants have sparse body hair and a few sweat or sebaceous glands (Feldhamer et al. 1999). Their body size results in large amount of metabolic heat apart from heat gain from the environment. The ambient temperature could increase the body temperature of elephants significantly (Buss and Estes 1971, Elder and Rodgers 1975, Weissenbock 2006). In the natural environment, elephants avoid getting exposed to heat load by using a number of behavioural mechanisms like increased resting in the shade during hot day hours with frequent dust bath, mud bath and ear flapping (Hiley 1975 and Baskaran 1998) and also by decreasing the time spent on feeding during the daylight hours in dry season as compared to wet season (Baskaran 1998). Wright and Luck (1984) have shown that the calculated heat loss from the ears of African elephants is substantial proportion of the total metabolic heat loss required and emphasized the importance of ear fanning. Similarly, Phillip and Heath (1992), using infrared thermography in the ear pinnae of the African elephants, have shown that temperature distribution across the pinnae changes with ambient temperature and up to 100% heat loss needs can be achieved by the movement of pinnae and by vasodilatation.

Asian elephants (Elephas maximus) in India are managed under captive conditions by Forest Department at the timber camps and zoos; by religious institutions at the Hindu temples, mutts, and mosques; and by private agencies at residential areas (Krishnamurthy 1998 and Vanitha 2007). In most of these places, except timber camps, the environment is much hotter than their natural habitats. Further, the daily routines of the elephants are modified according to the kind of work like daily rituals by temple elephants, cultural procession or begging by private elephants in captivity and after work they are mostly chained inside the enclosures. The enclosures are made of different types of roofing materials, namely, asbestos sheet (a construction material banned in many western countries), coconut frond thatching and reinforced cement concrete, which maintain the room temperature differently. The present study was carried out to understand the seasonal influence of ambient temperature and different roofing materials on the ear flapping frequency by captive elephants managed at six temples in Tamil Nadu, India, between May 2007 and April 2008.

Methods

Study area and animals

Six female elephants, ranging in age from 14 to 56 yrs, managed by six Hindu temples located within a radius of 50 km in Thanjavur and Nagapattinam districts of Tamil Nadu, India, were examined in this study. Every two of them were housed in the enclosures made of asbestos sheet, coconut frond thatching and RCC roofs. The study area experiences a prolonged summer lasting five months from March to July, a short rainy season from August to October and a winter period of four months between November and February with unusual rainfall occasionally. The maximum and minimum temperatures range from 37.8°C (mean maximum) in May to 19.1°C (mean minimum) in December (source: Tamil Nadu Rice Research Institute, Aduthurai).

Data collection

Data on time, frequency of ear flapping (randomly either left or right pinna) and major activities/routines such as daily rituals, fodder and cooked ration feeding, bathing and resting were collected using focal sampling method (Altmann 1974). At the end of every focal sampling, ambient temperature was recorded using a digital thermometer near the elephant's location. Behavioural observation on ear flapping was carried out on each elephant for a period of two days/month from 06:00 to 12:00 h and 12:00 to 18:00 h on consecutive days when there was no major difference in the climatic conditions for a period of one year. Each observation hour was divided into four sample blocks, with each block of 10 minutes observation and five minutes rest. The daily routines/activities of the elephants were broadly classified into three categories—fodder feeding and resting that take place inside the elephant house, daily rituals in which the elephant is placed inside the temple for the ritual and blessing devotees and other activities such as bathing, drinking, walking and concentrated diet feeding which occurs in open place in the temple or outside.

During the daylight hours (from 06:00 to 18:00 h), six elephants were kept in the temples for daily rituals for some time and the rest of the time in the enclosures for resting and green fodder feeding. The study also quantified the proportion of time spent on various activities in different hours of the day so as to differentiate the proportion of time the elephants were placed in the temples as well as in houses within each hour of the daylight hours. In majority of the cases when the elephants were placed inside the houses during afternoons, the mahouts would also go home. It was not possible to record the actual room temperature of elephant houses, as we were not permitted, for safety reasons, inside the elephant house. Room temperature data for the three house types was not available to compare directly with ear flapping rate. This lacuna was overcome by collecting data on maximum and minimum temperatures from houses with similar roof types in the same area for a period of five days.

Data analysis

Using data from all the elephants, the frequency of ear flapping and ambient temperature were computed in relation to different months of year and three different roofed (asbestos, coconut frond thatched and RCC) houses. Relationship between ear flapping frequency and ambient temperature during different months was tested using Spearman rank correlation through computer software Statistica (99 edition).

Results

Seasonal influence on ear flapping frequency

The rate of ear flapping in captive elephants varied remarkably in a 12-month period. It was the highest (9.2 times/minute) during May–June and dropped almost to half (5.7 times/minute) during December–January (Figure 1) coinciding with the highest and the lowest mean ambient temperature record of 36 + 3.42°C and 28 + 3.38°C, respectively. The ear flapping frequency and the ambient temperature recorded over 12 months showed a positive correlation (Spearman rank correlation $R = 0.839$, $P < 0.01$, $n = 12$).

Influence of various housing roofs on ear flapping frequency

The room temperature noted in three different roofed houses showed a remarkable difference in their range. The difference between maximum and minimum was the highest (mean of 12.7 + 7.0°C) in the asbestos-roofed houses (minimum and maximum 26.3–39 °C) and the lowest (2.7 + 2.0°C) in the coconut frond thatched houses (minimum and maximum 30.6–33.3 °C), while the RCC-roofed houses maintained an intermediate fluctuation (4.3 + 2.5°C) in room temperature (minimum and maximum 31–35.3°C).

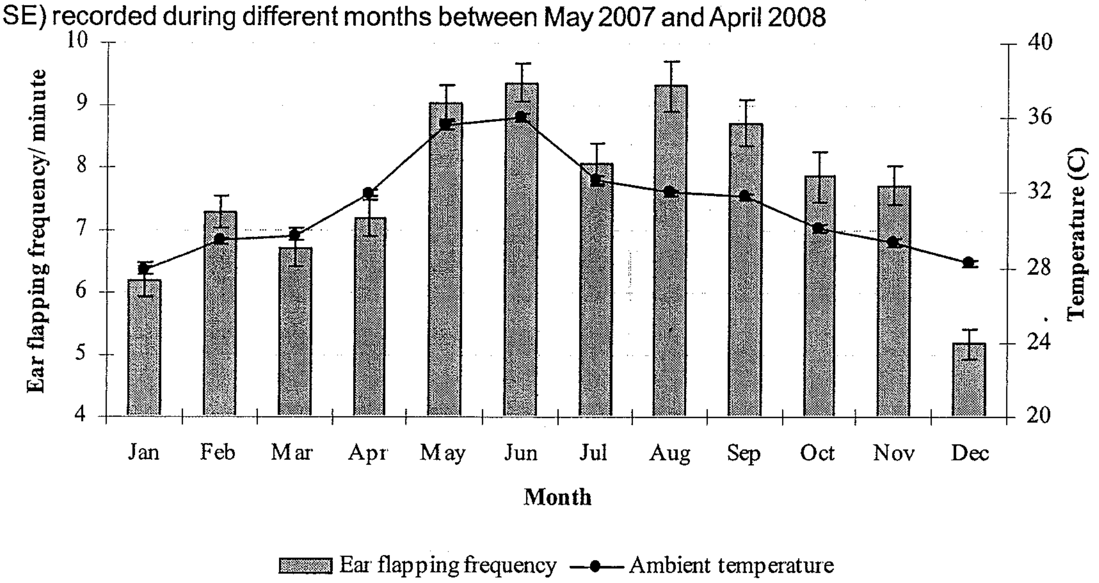
Among the three types of roofs evaluated, elephants from the granite-roofed temple yards, when brought to asbestos roofed houses around 12:00 h, showed a sudden spurt in the mean rate of ear flapping from about 6 times/minute between 11:00–12:00 h to nearly 10 times/minute between 12:00–13:00 h and the flapping rate remained at around 8 times/ minute until 15:00–16:00 h (Figure 2a). After 16:00 h, it reduced to < 6.5 times/minute when the elephants were taken out from the house to temple yard for daily rituals (Figure 2b). On the other hand the other two elephants, when brought to the coconut frond thatched houses, during afternoon time around 13:00 h, a remarkable drop was observed in the ear-flapping rate (Figure 2c & 2d). On the contrary, those brought under the RCC-roofed houses showed a gradual increase in ear flapping rate even after 12:00 h, reaching the peak by 13:00 h and then gradually declined (Figure 2e & 2f). In this case, the rate of ear flapping gradually increased even after they were brought to the elephant houses, as RCC roofs maintained room temperature only moderately unlike coconut thatched house as shown by the maximum and minimum temperature data in different houses.

Discussion

Since heat dissipation could be a problem for elephants, especially in the warm tropical environment, under the natural condition they avoid exposing to heat load by using a number of behavioural mechanisms like resting in the shade during hot day hours with frequent dust and mud baths and ear flapping (Hiley 1975, Baskaran 1998). The high surface-to-volume ratio of the ear pinnae (Wright 1984) along with the prominent and extensive vascular network (Sikes 1971) and their mechanism of vasodilatation with an increase in blood flow and simultaneous frequent ear flapping under warm conditions increase convective heat loss (Wright 1984). Weissenbock (2006) using infrared camera on Asian elephants in Sri Lanka has shown a positive correlation between body surface temperature and ambient temperature and this study has also revealed that the surface temperature of ear pinnae approximated the ambient temperature in the morning hours and exceeded the same during the day hours indicating the role of ear pinnae in thermoregulatory mechanisms.

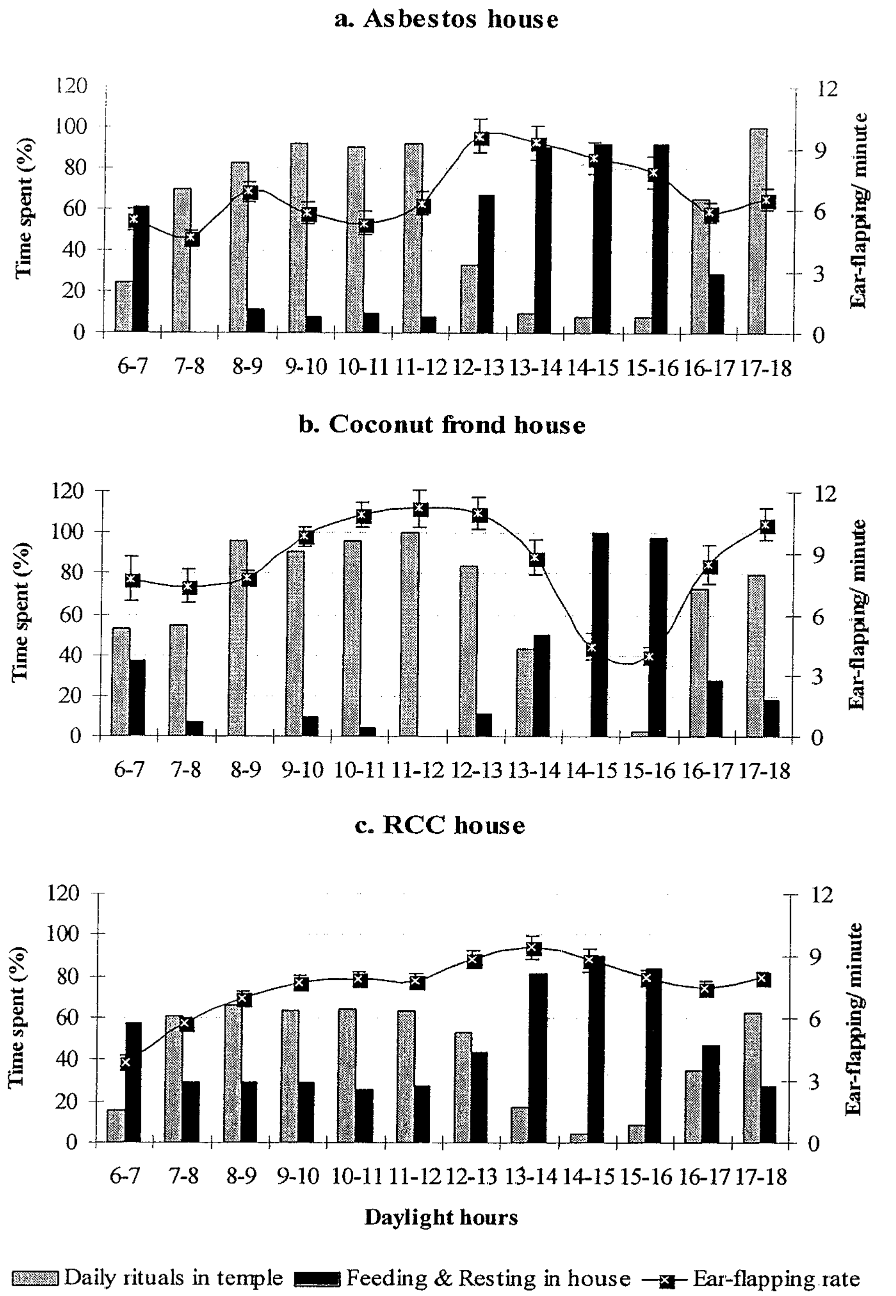
The study area of Nagappattinam and Thanjavur districts being located in the plains region experiences relatively higher ambient temperature unlike the natural habitats of elephants, which are mostly in the Ghats or high rainfall areas. Additionally, the prolonged dry spell in the study area could also influence the body temperature remarkably. The positive increase in the ear-flapping rate with the ambient temperature observed during daylight hours indicates that the environmental temperature influences the rate of ear flapping among elephants. In general, summer season in the study area commences in March and continues up to July with

Figure 1: Mean frequency (± SE) of ear flapping by captive elephants and mean ambient temperature (± SE) recorded during different months between May 2007 and April 2008



maximum temperature remaining above 35°C during April–June. The rainy season starts in August and ends in October and thereafter climate turns into cool winter season with temperature ranging from a minimum 19°C to a maximum 32°C during November–February support the fact that ambient temperature influences the ear flapping rate of elephants. These results are in accordance with the findings of Buss and Estes (1971) and McKay (1973), who have observed an increase in ear flapping rate

Figure 2: Mean rate (+ SE) of ear flapping and daily routines in relation to daylight hours among captive elephants housed in shed with asbestos, coconut frond and RCC roofs



Note: Ear-flapping rate increased suddenly around 13:00 h when the elephants were brought from granite-roofed temple yards to the asbestos- roofed elephant houses (Fig. 3a). On the other hand, its frequency decreased remarkably when brought to coconut frond thatched houses (Fig. 3b) and there was no remarkable change in RCC houses (Fig. 3c).

with ambient temperature.

The results on room temperature suggest that asbestos roof merely absorbs the heat from ambient temperature and radiates to the interior part of room unlike coconut frond roof, which reflects the heat outside and thus keeps the room temperature without much fluctuation. In support of this, studies of Roma et al. (2008) have shown that asbestos sheet transfers temperature inside room significantly more than tiles reinforced with vegetable fibers. Therefore, asbestos roof houses tend to have the highest maximum and lowest minimum temperatures, respectively, during mid-day and night hours resulting in wide fluctuations in room temperature. Further, asbestos has been banned in many western countries, as it is known to cause serious health problems such as lung cancer and respiratory diseases among human beings (Doll and Peto 1985, Mossman 1993). The roof made of RCC has an intermediate fluctuation indicating that it is moderate in maintaining the room temperature. Therefore, elephants housed under the three types of roofs are expected to have different levels of ear flapping rate, as ambient temperature levels are different in these houses.

Of the three houses examined, elephants rapidly increased their ear flapping frequency after 13:00 h when brought to the house made of asbestos sheet roof. Contrarily, in the case of coconut frond roof houses, elephants decreased their ear-flapping rate remarkably after 13:00 h when they were brought to the houses. Unlike the above two cases, the elephants brought to RCC roof houses without any sudden response to house environment continued increasing their ear flapping gradually. The rate of ear flapping and the variation in temperature observed in the three types of houses reveal the positive influence of room temperature on the ear flapping frequency. The large body size results in greater metabolic heat (Phillips and Heath 1992) and thus cools slower than smaller animals since the surface area-to-volume ratio decreases with increasing body size (Schmidt-Nielson 1984). Further, their sparse body hair and a few sweat glands (Feldhamer et al. 1999) impose constraints in heat dissipation and therefore prefer cool temperature. On the contrary, asbestos roofs do not maintain room temperature. Therefore, in view of the present findings, some modifications are suggested to elephant house roofs to reduce the heat on the elephants.

Conclusion

The effects of adverse seasonal climate (temperature) are compounded by the undesirable properties of asbestos used in roofing of the elephant housing. Such situations exist not only in the study area, but elsewhere too. Therefore, some of the recommendations made here may be applicable to other areas also, where similar conditions on climate and/or roofing of the elephant housing exist.

§ The present study assessed the influence of ambient temperature in different seasons and housing roofs on the ear-flapping frequency among six captive elephants managed in Hindu temples in Tamil Nadu between May 2007 and April 2008.

§ The comparison of mean monthly ear-flapping frequency with mean monthly ambient temperature showed a positive correlation with the highest ear-flapping rate during summer (May–June) and the lowest during winter months (Dec–Jan) indicating the significant influence of ambient temperature on this physiological response. Captive elephant facilities need to keep in mind the seasonal influence of temperature on the physiology of elephants and schedule their workload accordingly.

§ Among the three different houses, ear-flapping rate increased suddenly around 13:00 h when the elephants were brought from granite-roofed temple yards to the asbestos- roofed elephant houses. On the other hand, its frequency decreased in coconut frond thatched roof, and there was no remarkable change in RCC houses. The relatively higher room temperature recorded in asbestos-roofed houses and the lower room temperature in the coconut frond thatched houses could have respectively increased the ear flapping in asbestos houses and decreased in coconut frond houses. RCC houses with a moderate temperature fluctuation gradually reduce the rate of flopping of ears.

§ Based on the findings we suggest that asbestos roofs be eliminated as they do not maintain the temperature unlike the coconut fronds and thus are unsuitable as far as elephant physiology is concerned, especially in warm places like the plains of Tamil Nadu. Further, asbestos is known to cause serious health problems such as lung cancer and respiratory diseases among human beings (Doll and Peto 1985, Mossman 1993). Therefore, roofs made with asbestos need to be replaced urgently ideally with coconut fronds. False roofs of coconut fronds be built on existing RCC houses (on the upper side) or a shade tree be planted on the sides of elephant houses to minimize the exposure of RCC roof to the solar heat load.

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Authors

1. Vanitha V.
Postgraduate and Research Department of Zoology and Wildlife Biology, A.V.C. College, Mannampandal, Tamil Nadu

2. Dr.Baskaran N.
Asian Nature Conservation Foundation,

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