Universidade de Trás-os-Montes e Alto Douro

Influence of different captivity conditions in African and Asian elephants' behaviour.

Preliminary Study

Dissertation of Integrated Masters in Veterinary Medicine

Ana Catarina Silva Pinto

Supervisor: Professor Doutor Bruno Jorge Antunes Colaço

Vila Real, 2014

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Declaração

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Declaro que esta dissertação de mestrado é resultado da minha pesquisa e trabalho pessoal e das indicações do meu orientador. O seu conteúdo é original e todas as fontes consultadas estão devidamente mencionadas no texto e na bibliografia final. Declaro ainda que este trabalho não foi apresentado em nenhuma outra instituição para obtenção de qualquer grau académico.

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Resumo

Os elefantes Africanos e Asiáticos são considerados espécies ameaçadas e as suas populações continuam a decrescer. Inúmeros esforços têm sido feitos de forma a contrariar esta tendência. Os Zoos têm um papel muito importante no que toca à conservação da vida selvagem, desenvolvendo projectos de investigação e programas educacionais. Portanto, a existência de animais em vias de extinção em cativeiro é uma mais-valia para a sua sobrevivência. No entanto, estas instituições têm de mostrar ao público que a sua missão principal é a conservação de espécies, e que durante este processo todas as medidas com vista a garantir o bem-estar animal são acauteladas.

O objectivo principal deste trabalho é avaliar as variações das manifestações comportamentais das diferentes populações de elefantes nos Zoos face às diferentes variáveis ambientais a que estão sujeitos. Para alcançar este objetivo, foram colhidos dados em cada Zoo sob a forma de questionários e de vídeos comportamentais de elefantes, que foram depois analisados estatisticamente.

Observamos que a presença do macho influencia nas fêmeas os comportamentos de alimentação, locomoção, vocalização e comportamentos estereotipados. O comportamento de “dusting” e os movimentos das orelhas estão diretamente relacionados com o aumento da temperatura. Os dispositivos de enriquecimento levam a um aumento do comportamento de brincadeira, mantendo os animais mental e fisicamente ocupados. O enriquecimento alimentar que leva a um aumento do comportamento de alimentação é um factor positivo no que toca a comportamentos estereotipados, já que estes não são tantas vezes manifestados quando esse tipo de enriquecimento é praticado. Também pudemos observar que a existência de grupos sociais leva à realização de comportamentos mais semelhantes aos seus co específicos selvagens.

Podemos concluir que a avaliação do comportamento dos elefantes em cativeiro permite auxiliar a adoptar medidas com vista a melhorarem os procedimentos de maneio em cativeiro, de forma a diminuir o impacto negativo na vida dos animais levando a uma melhor conservação.

Keywords: Elefantes; comportamento; estereotipado; cativeiro.

Abstract

African and Asian elephants are listed as threatened species and their populations continue to decline. Lots of efforts have been made to counter this tendency. Zoos have an important role to play in terms of Wildlife conservation, developing projects in the wild, alongside research and education programs. So, the existence of endangered species in captivity is important for their survival in the wild. Zoos must make clear to the general public that their mission is one of conservation, which is conducted with the highest welfare standards.

The main objective of this project is to evaluate the behaviours' variations in different Zoo populations regarding the effect of diverse environmental variables. To achieve this, in each Zoo was collect data through two methods: a survey and videos of elephant behaviours that were statistical analysed afterwards.

We observed that the presence of the male has an influence on females' foraging, locomotion, vocalizations and stereotypic behaviour. Dusting and ears' flapping behaviours are directly related with the environmental temperature. The enrichment devices lead to an increase in the play behaviour, keeping the elephants mentally and physically occupied. The nutritional enrichment which leads to an increased the foraging behaviour is a positive factor regarding stereotypic behaviours as they are not performed as often as when such enrichment is practiced. Also, the existence of social tiers and groups leads to the performance of most similar behaviours as their wild conspecifics.

We can conclude that the assessment of elephant behaviour in captivity will help to adopt measures to improve the management procedures that will have lower impact in the animal's life leading an optimized conservation.

Keywords: Elephants; behaviour; stereotyipic; captivity.

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List of abbreviations and acronyms

IUCN	International Union for Conservation of Nature
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
ESU	Evolutionary Significant Units
TGS	Temporal Gland Secretion
LH	Luteinizing Hormone
ovLH	Ovulatory surge
anLH	Anovulatory surge
UD	Urine Dribbling
AZA	Association of Zoos and Aquariums
EAZA	European Association of Zoos and Aquaria
OOS	Out of sight
P	Present
A	Absent

I. Literature Revision

1. Introduction

The IUCN (International Union for Conservation of Nature) Red list for threatened species list as vulnerable the African Elephant, as endangered the Asian Elephant and as critically endangered the Sumatran Asian Elephant.

Therefore, the Asian species is the most endangered extant elephant, with fewer than 55,000 individuals remaining compared to more than 500,000 African elephants (Fleischer, *et al.*, 2001).

The African Elephant is listed by CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) in Appendix II[1] for populations of Botswana, Namibia, South Africa and Zimbabwe, and in Appendix I[2] for all the others populations. The Asian Elephant is listed in Appendix I.

The major threats that African Elephant have been facing are the poaching for ivory and meat. However, currently the most important perceived threat is the loss and fragmentation of habitat, causing the species' decline. This is the major threat for Asian elephant as well, due to the expanding of human population, leading to more and more conflicts between humans and elephants (Leimgruber, *et al.*, 2003).

Zoos are great contributors for conservation, and this is not a new concept for the Zoo community. Zoos have been developing conservation's projects in the wild, alongside research and education programs (Conde, *et al.*, 2011). Still, in many countries, historical and social perceptions of Zoos as entertainment menageries still persist, and in some cases are justified. A sector frequently hostile to Zoos is the growing animal-rights and animal-welfare lobby, so they must make clear to the general public that their mission is one of conservation, which is conducted with the highest welfare standards. Therefore, the ethical and welfare issues involved in managing wild animals in collections need to be constantly assessed and evaluated (WAZA, 2005).

Regarding the elephants, there is relatively little scientific work done to quantify elephant welfare in different Zoo housing and management systems (Clubb & Mason, 2002).

[1] Appendix II lists the species that are not necessarily threatened right now with extinct but may become so, unless trade is closely controlled.
[2] Appendix I list species that are threatened with extinction, the most endangered among CITES. Trade in these species, or even parts of them, is completely banned, except for rare cases such as scientific research.

The assessment of elephant behaviour will help to adopt measures to improve the management procedures that will have lower impact in the animal's life leading an optimized conservation and be relevant to wild population because captive and wild elephants demonstrate many of the same behaviours (Schulte B. A., 2000).

In this dissertation the literature revision will incorporate three main issues: The elephant biology which is going to be focused on their taxonomy, anatomy and morphology; their behaviour in the wild; and the last part which will be centred on elephants in captivity.

2. Elephant Biology

2.1. Taxonomy

The last survivors of the Proboscidea order are the three living species of elephants, the forest African elephant (*L. cyclotis*), the savannah or bush African elephant (*L. africana*) and the Asian elephant (*E. maximus*) (Shoshani & Tassy, 2005; Rohland, *et al.*, 2010). They belong to the Elephantidae family with two generus, the *Elephas* and the *Loxodonta* (Figure 1) (Shoshani & Tassy, 2005).

K: Animalia
P: Chordata
C: Mammalia
O: Proboscidae
F: Elephantidae
G: *Loxodonta*
Sp: *Loxodonta Africana*
Loxodonta cyclotis
G: *Elephas*
Sp: *Elephas maximus*
Subsp: *Elephas maximus maximus*
Elephas maximus indicus
Elephas maximus sumatranus

1 Taxonomy diagram for the elephant species

To some scientists, the Loxodonta group should only consist in one species with two subspecies, the *L. africana africana* and the *L. africana cyclotis*. They claim that there is no satisfying argument which can recognize two or more species of African elephants (Debruyne, 2005).

Yet, they live in very different habitats (forest African elephant lives mainly in rainforests and swamps where is wet and shady, while savannah elephant can live mainly in deserts where is hot and dry) and they have some morphologic differences which are going to be described in the next chapter. Also, the hybridization of gene flow between forest and savannah elephants are extremely limited, even near regions of potential physical contact as in north-central Africa or near Garamba, supporting the recognition of two African species: *Loxodonta africana* and *Loxodonta cyclotis* (Roca, *et al.*, 2001).

The classification into divergent species was recent supported by morphological studies and nuclear DNA analyses (Ishida, *et al.*, 2011). This last showed that the two African elephants are as or more divergent in the nuclear genome as mammoths and Asian elephants, and this two are considered to be distinct genera, supporting the classification into two highly divergent species (Rohland, *et al.*, 2010; Ishida, *et al.*, 2011).

In 2002, Eggert reported on what might be interpreted as a possible third species of African elephant for the populations of the forest and savannah elephants of West Africa due to 3 distinct genetic and ecological lineages proposed from DNA studies, suggesting that the West African populations have been isolated from other elephant populations for as long as 2.4 million years (Eggert, *et al.*, 2002; Shoshani & Tassy, 2005). However, these interpretations are not widely accepted, and need possible further investigation (Shoshani, 2006).

The *Elephas* group have three recognized subspecies: the Sumatran Asian Elephant (*E. m. sumatranus*), the Mainland or Indian Asian elephant (*E. m. indicus*), and the Sri Lankan Asian elephant (*E. m. maximus*) (Shoshani & Eisenberg, 1982; Fleischer, *et al.*, 2001; Shoshani & Tassy, 2005).

The differences between these subspecies are related with the number of ribs, body size, ear size, tusk size, skin depigmentation and others features (Shoshani, 2006).

Some scientists tried and are trying to prove that the elephants from Borneo islands should also be considerate a different subspecies of the Asian Elephant, as they were initially (Fernando, *et al.*, 2003). This prior subspecies was subsumed under the Mainland and Sumatran subspecies because they were considerate as non indigenous in Borneo since they believe they were introduced 300 to 500 years ago by humans and there was a lack adequacy of the original description of *E. m. borneensis* in terms of the morphological characters assessed and sample size (Fernando, *et al.*, 2003; Cranbrook, *et al.*, 2007). The hypothesis of the introduction was rejected due to mitochondrial and microsatellite analyses indicating that they are genetically distinct, with molecular divergence, and therefore they are indigenous to the Island (Fernando, *et al.*, 2003). Nevertheless, further studies should be performed to repeat and corroborate these findings because the origin of the Borneo Elephant is still controversial (Shoshani & Tassy, 2005; Alfred, *et al.*, 2012).

The Sumatran elephant is usually separated from the other two subspecies in terms of conservation because they are monophyletic and consequently could be defining as an ESU (Evolutionary Significant Units) as they should be reciprocally monophyletic for mtDNA alleles and show significant divergence of allele frequencies at nuclear loci (Moritz, 1994; Fleischer, *et al.*, 2001). This concept was developed to provide a basis for prioritizing taxa for conservation effort, given that resources are limited and that existing taxonomy may not adequately reflect underlying genetic diversity (Moritz, 1994).

2.2. Morphologic differences between elephants

2.2.1. African and Asian Elephants

The main morphologic differences between African and Asian elephants are regarding with body weight, height at shoulder, skin, number of ribs, size of ears, shape of back, shape of head, tusks, trunk, tip of the trunk and the number of nail-like structures (Table 1 and Figure 2).

Table 1 - Main morphological differences between the two elephants groups. Adapted from Shoshani & Eisenberg (1982), Schmidt (1986) and Shoshani (2006).

Characteristic	*Loxodonta africana*	*Elephas maximus*
Weight	4000Kg to 7000Kg;	2000 and 5000Kg;
Height at shoulder	3 to 4 meters;	2 to 3.5 meters;
Skin	More wrinkled;	Smoother;
Number of ribs	Up to 21 pairs;	Up to 20 pairs;
Size of ears	Big and large ears, exceeding the height of neck;	Smaller ears, which do not exceed the height of neck;
Shape of back	Concave;	Convex or level;
Shape of head	No compression, no bulges and no dish;	Compressed antero-posteriorly, dorsal bulges and dished forehead;
Tusks	Present in both sexes (larger in males);	Males - usually carry the tusks; Females - tusks are vestigial or absent (tushes);
Trunk	More annulated and less rigid;	More rigid, less annulated;
Tip of the trunk	"Two-fingers";	"One-finger";
Number nail-like structures (toes)	Usually 4 in the forefeet and 3 in the hindfeet.	5 toes in the front feet and usually 4 in the hind feet.

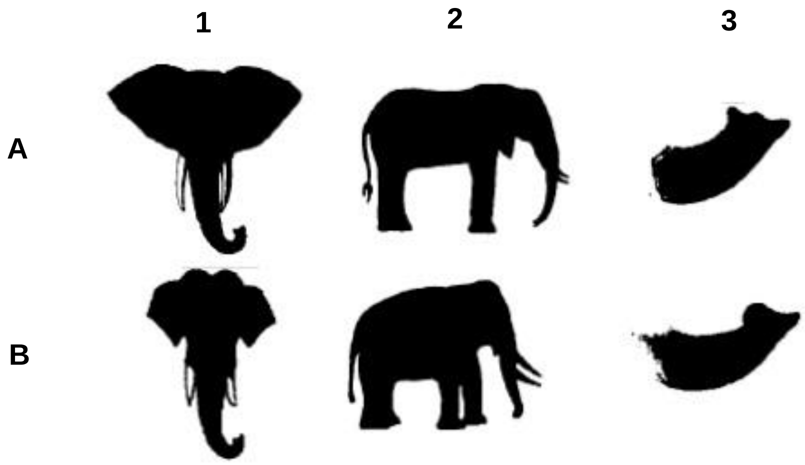


Figure 2 - Differences between African elephant (A) and Asian Elephant (B) regarding the size of the ears and the shape of the head (1), the back (2) and the tip of the trunk (3). Adapted from Shoshani (2006)

2.2.2. Within the African Elephants

The *Loxodonta cyclotis* (Forest elephant) is more alike the Asian elephant regarding the weight and the height to the shoulder. They weigh between 2000Kg and 4500Kg and only reach 2 to 3 meters at shoulders length. The tusks are slender, straighter and down-pointing which is the opposite of the Savannah elephant (Figure 3). These are probably the main differences between this two species (Shoshani, 2006).

Compared with *L. africana*, the *L. cyclotis* seems to have darker skin, rounded ears, longer mandible and their skull is less pneumatised. The nail-like structures in adults of the Forest elephants are the same as the Asian elephant (Shoshani, 2006).

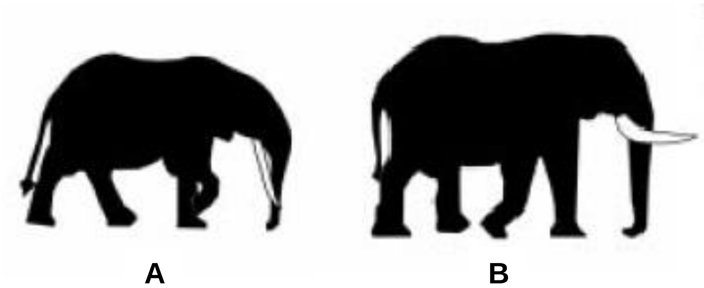


Figure 3 - Forest Elephant (A) and Savannah Elephant (B). Adaptaded from Roca (2001)

African elephants held in Zoos are almost exclusively of the savannah species, and therefore, for the purpose of this dissertation discussions about “African Elephant” will be limited to *Loxodonta africana* (Clubb & Mason, 2002).

2.2.3. Within the Asian Elephant

As previously mentioned, there are three subspecies of Asian Elephants.

The *E. m. maximus* is the one with the darker skin and with large and distinct patches of depigmentation on ears, face, trunk and belly. The *E. m. sumatranus* is the one with the lightest skin and with least depigmentation, and also, the smaller one. The skin of *E. m. indicus* is between the other two subspecies regarding these two characteristics (Shoshani, 2006).

The ears of the *E. m. maximus* are usually the largest ones, but the ears of the *E. m. sumatranus* appear larger comparing to the body size (Shoshani, 2006).

Only the Sumatran Subspecies has 20 pairs of ribs, whereas the other two only have 19 pairs of ribs. This is one of the reasons that probably make this subspecies the most primitive one within the Asian species (Shoshani, 2006).

2.3. Anatomic particularities

Elephants anatomy compared to other mammals have some particularities worth knowing. Some have already been described in the latter chapter and the important features related with elephants behaviour and life, are described in this chapter such as teeth, tusks, trunk, temporal gland and reproductive tract.

Elephant's teeth are unique in a diversified way. They have six complete sets of grinding teeth during their lives, and they are referred as molars. Each set of teeth has four molars, as they have two molars per jaw. They are covered with enamel and each molar consists of complex lamellae with cement between them. (Schmidt, 1986; Kuntze, 1999). The first molars are worn away and their roots are reabsorbed as the second molars come forward. Each succession of molars is regular and each set becomes progressively larger. The sixth set of molars is usually worn away when the elephant has approximately 60 years old, and therefore, when this happens the animal is unable to feed properly and starve to death. Thus, teeth are the factor that estimates the lifelong of an elephant (Table 2 and Figure 4) (Schmidt, 1986).

Table 2 - Molar information. Adapted from Waters (2014)

Molar	Eruption	Replacement
1	4 months	2-2.5 years
2	6 months	6 years
3	3 years	9 years
4	6 years	25 years
5	20 years	50-60 years
6	40 years	60+ years

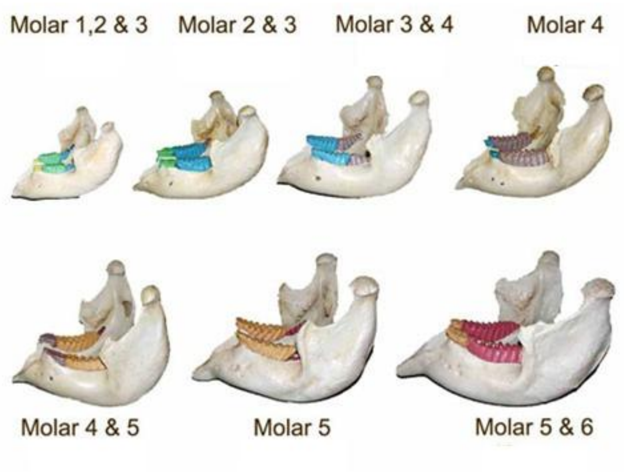


Figure 4 - Molar scheme. Adapted from http://pomposa.livejournal.com/10235.html

Tusks in elephants are modified incisors, and they are used for numerous tasks, such as digging, carrying and behavioural displays (Schmidt, 1986; Weissengruber, *et al.*, 2005). In early development they are covered with enamel, which is rapidly worn way leaving only dentin (ivory) surrounding a pulp canal. During their lives, the alveolar process which contains one third of the tusk is continually growing to accommodate the growth of the tusks (Schmidt, 1986).

The elephant trunk it's a large, heavily-muscled structure and it's unique to the proboscidea order (Schmidt, 1986). It is actually an extension of the nose and upper lip and the elephant uses it to breath (70% through the trunk and 30% through the mouth), to drink, to eat, to manipulate objects, and to communicate (Schmidt, 1986; Kuntze, 1999). In vocal communication, elephants share with other mammals the basic source and filter vocal production anatomy (lungs, trachea, larynx (including the vocal folds), pharynx, and the nasal and oral cavities), but they also have two other anatomical structures standing out that may influence vocal output by affecting the size and shape of the vocal tract, the pharyngeal pouch and the hyoid apparatus. The pharyngeal pouch is a pocket like structure in the elephant throat, which is thought to function as a water storage vessel and the hyoid apparatus is divided into loosely connected upper and lower sections, allowing flexibility of laryngeal movement (Shoshani & Tassy, 2005; Soltis, 2010).

The skin of the trunk tip finger houses a high density of free nerve endings, numerous small corpuscles, and vellus vibrissae (Rasmussen & Munger, 1996). These features allow the trunk tip to detect vibrations, finely manipulate objects and transfer liquids. The small corpuscles are known as pacinian corpuscles that are primary mechanoreceptors known to respond to mechanical deformation and vibratory stimuli. These corpuscles also exist in elephant tongue and elephant feet, and they serve as an important mechanism for detecting seismic information (Kubota, 1967; Rasmussen & Munger, 1996; Weissengruber, *et al.*, 2006).

African and Asian elephants have temporal glands, unique in these species. They are integumentary glands and are derived from apocrine sweat glands (Shoshani & Eisenberg, 1982; Rasmussen & Schulte, 1998). They are located subcutaneously, midway between the eye and the ear on each side of the head. (Shoshani & Eisenberg, 1982).

Probably the most remarkable characteristic of the female elephant reproductive tract is its size as it is the longest among all land mammals with about 3 meters length (Figure 5) (Hildebrandt, *et al.*, 2011).

Ovaries are relatively small in elephants (averaging 55–65mm), and they are enveloped in a serosal pouch, which forms the oviductal infundibulum and is incorporated into the two ovarian bursae (Schmitt, 2006; Hildebrandt, *et al.*, 2011).

The uterus is 0.8 to 1.5 m long and is characterized by a short uterine body, with about 15 cm long that splits into two long uterine horns (Schmidt, 1986; Hildebrandt, *et al.*, 2011). The endometrium show longitudinal rugae and each pregnancy leaves a permanent damage on it, which is repaired by scar tissue afterwards. Therefore, the number of pregnancies can be determined during autopsy by counting these scars (Hildebrandt, *et al.*, 2011).

The cervix is very similar to the mares, with longitudinal folds. Its opening protrudes into the vagina with an appearance of a rosebud, and it's about 15 cm (Schmitt, 2006; Hildebrandt, *et al.*, 2011).

The vagina has many longitudinal folds and extends to a length of up to 50cm. Unlike most other species, the elephant penis does not penetrate the vagina for semen deposition, he only reaches the vestibule, very close to the vaginal os where the semen is partially sprayed with high pressure into the vagina, explaining why retrograde semen loss has been observed after mating and the need for multiple mating (Hildebrandt, *et al.*, 2006; Schmitt, 2006; Hildebrandt, *et al.*, 2011).

The vestibule has approximately 1.3 meters length and it opens at the vulva between the hind legs. It's a tube like structure and it runs vertically to under the anus and then horizontally at the cranial end in the caudal pelvis, forming a 20- to 40-cm long a sac. At its cranial end the hymeneal membrane is found, and as opposite as the other species it doesn't rupture during copulation but during the first parturition. This vaginal os is guarded left and right by two blind pouches of similar size, thought to be remains of Wolffian ducts (Schmitt, 2006; Hildebrandt, *et al.*, 2011).

Figure 5 - Female reproductive tract. Adapted from Waters (2014)

In males, the testes are located intraabdominally, which can reach up to 2 Kg in an adult bull (Figure 6). Elephants' testes don't have pampiniform plexus, which assists the cooling in scrotal mammals, because temperature in elephants is low (between 34 to 36ºC). Therefore, pampiniform plexus is not that important in elephants, as they already have the "perfect" temperature to allow the optimal spermatogenesis (Hildebrandt, *et al.*, 2006; Schmitt, 2006).

Elephants possess all accessory sex glands, the bulbo-urethral glands, prostate, seminal vesicles and ampullae. The only notable species difference in the reproductive anatomy between Asian and African elephants is the size and shape of the lobulated prostate gland, which in African elephant are larger (approximately 5cm on each side) and contain irregular-shaped internal cavities with prominent glandular tissue in each of the three lobes and in Asian elephants it is only 2 cm diameter and the tissue is homogeneous (Hildebrandt, *et al.*, 2006; Schmitt, 2006).

The penis has approximately 100 cm long and 16 to 20 cm in diameter. The erect penis has an S-shaped curve and the paired levator muscles are large. They allow the penis to be very mobile letting it to move independently of the pelvis and therefore, during mating, the male doesn't need to perform many moves for intromission (Schmitt, 2006).

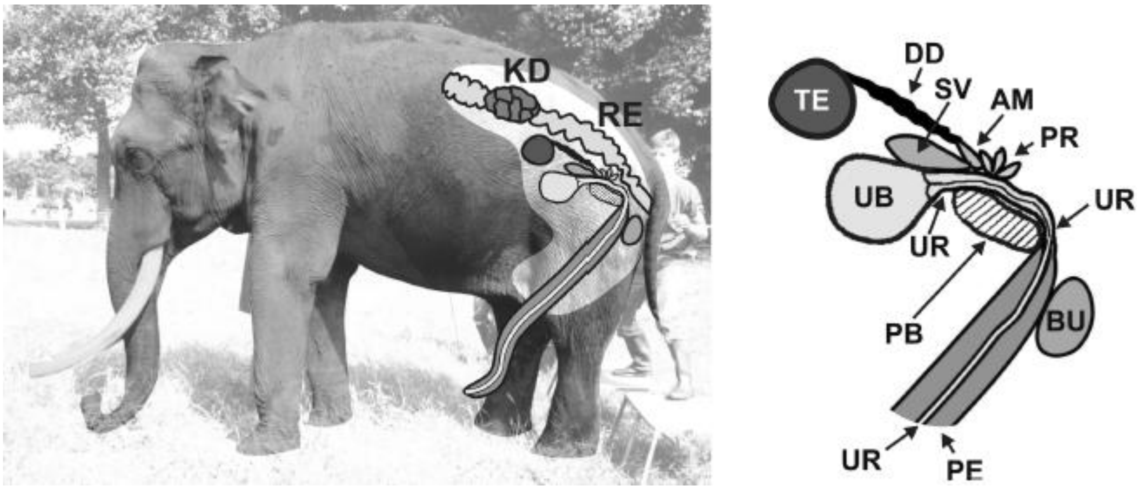


Figure 6 - Schematic diagram of the reproductive tract of the male. KD – kidney; RE - rectum; TE - testis; DD - ductus deferens; AM - ampulla; SV - seminal vesicle; PR - prostate; BU - bulbo-urethral gland; UB - urinary bladder; UR - urethra; PE - penis; PB - pelvic bone. Adapted from Hildbrant (2006)

These unique morphologic features make their behaviour a lot different from any other mammal.

3. Behaviour in the wild

Elephants are highly social animals. For that reason, they have a very complex social behaviour regarding their interactions with each other. Their individual one is more related with their sexual and body care behaviour. Both will be explained in this chapter.

3.1. Social Behaviour

3.1.1. Social Structure

Female elephants are philopatric (tendency of an organism to stay in, or return to, its home area) and closely bonded to their relatives. They live in matrilineal family units, led typically by the oldest female, the matriarch, who plays a key role in coordinating group movements and responses to threat (Vidya & Sukumar, 2005 B; Wittemyer & Getz, 2007; Gobush & Wasser, 2009; McComb, *et al.*, 2011).

The family group generally consists of 4–12 individuals for the African savanna species and 6-8 for the Asian subspecies, although smaller and larger groups can also be found (Clubb & Mason, 2002; Schulte, 2006).

The African elephant fission-fusion social organisation is well described, unlike the Asian Elephant, which only few studies about their social organisation have been published (Vidya & Sukumar, 2005 A; Wittemyer & Getz, 2007; Silva & Wittemyer, 2012).

There are empirically delineated four social tiers among female African elephants (Wittemyer, *et al.*, 2005; Silva & Wittemyer, 2012). The first tier units are defined as mother-calf units, with a breeding female and her sexually immature offspring (Wittemyer, *et al.*, 2005; Charif, *et al.*, 2005; Silva & Wittemyer, 2012). If the offspring is male, he will leave the mother in the puberty age and form loose association with other males, the bachelor groups, or live by his own (Rasmussen & Schulte, 1998; Vidya & Sukumar, 2005 B). Bonds between males are weak as they rarely spend more than 10% of their time with other male. They only associate with female groups during breeding season (Archie & Chiyo, 2012). If the offspring is female, she will grow and will stay with the family group, as female elephants are generally believed to remain in natal units through their lives (Wittemyer & Getz, 2007). The second tier units are the association of one or more adult female elephants (most probably relatives) and their immature offsprings, i. e. associations of the first tier, and they are referred as “family” or “core groups” (Rasmussen & Schulte, 1998; Wittemyer, *et al.*, 2005; Gobush & Wasser, 2009; Silva & Wittemyer, 2012). The third tier units correspond to “bond groups” composed of multiple second tiers units, which in turn are nested within tier four groups, the “clans” (Wittemyer, *et al.*, 2005; Vidya & Sukumar, 2005 A; Silva & Wittemyer, 2012).

In 2005, Wittemyer described that the family unit was stable across season, but the third and fourth tiers were responsive to ecological changes such as season. In dry season, where there are few resources and the competition for food increases, the social cohesion of these two elephant units decreases (Wittemyer, et al., 2005; Vidya & Sukumar, 2005 A; Schulte, 2006).

In addition, age structure also appears to influence this social organisation, as the herds lead by matriarchs likely to be grandmothers (i.e. females 35 years and older) seems significantly larger than those lead by younger matriarchs (Wittemyer, *et al.*, 2005).

So, the social units tend to be related, but coalescence of unrelated individuals into a social unit is not impossible, and may be more frequent after extreme alteration of family structure, which can occur, for example, through poaching (Schulte, 2006).

Poaching disrupts kin-based association patterns, decreases the quality of elephant social relationships and increases the male reproductive screw as they tend to poach the larger males with larger tusks for ivory, and so the male population decreases, leading to significant consequences for population health and the maintenance of genetic diversity (Archie & Chiyo, 2012).

Overall, in this multilevel fission-fusion society, the nested hierarchy of social tiers can be separated into smaller units during times of constraints, down the hierarchy, or building it up when fusing into larger units to increase cooperative benefits (as in breeding season by attracting males, which may be the reason that individuals coalesce into third tier units more frequently during the wet season) (Wittemyer, *et al.*, 2005).

As was said before, elephants in tier units tend to be closely related. The mechanism that maintains these ties among distant maternal kin is unknown. One of the possibilities is that calves learn which groups they are familiar with and maintain those ties when they become adults. In addition to that, social groups that were once part of the same core group might continue to maintain similar home ranges, and therefore, they might have to interact and form a group (Archie & Chiyo, 2012).

Asian elephants also travel in family units, but bond and clan level aggregations apparently do not occur or are not as common as in African elephants. So, as expected, individuals in the African populations form larger groups and are much more strongly associated with their social units and with the population in general (Schulte, 2006; Silva & Wittemyer, 2012).

In both Asian and African elephant society, calves are the core of the elephants' herd. Within the social group, related females, especially young and nulliparous females, are engaged as allomothers (Schulte, 2006; Silva & Wittemyer, 2012). Allomother is defined as the maternal behaviour provided by a female that is not the calf's mother. They often are older daughters that help their mothers with the newborn. They can be called "auntie" as well, and the main difference between both is that the allomother provides a more prolonged assistance (Kahl & Santiapillai, 2004). Allomothers may also benefit from the experiences of caring for the young of another female and when competition for resources is high, they can gain access to resources from older elephants, in exchange for providing alloparental care (Schulte, 2006; Gobush & Wasser, 2009).

Because residency within the natal herd is typically lifelong, strong bonds are established and information is accumulated, thus, relatives and older animals are especially valued social partners (Schulte, 2006; Archie & Chiyo, 2012). As typically the oldest individuals in a female group, matriarchs facilitate learning as other herd members imitate their actions (Gunawardene, et al., 2004; Schulte, 2006). For example, following playbacks of less familiar elephants, herds with older matriarchs were more likely to display investigative smelling behaviour than herds with younger matriarchs, showing greater caution and exploratory behaviour (McComb, et al., 2001; Vidya & Sukumar, 2005 A; Schulte, 2006). The social group has also direct benefit, because the older leader as enhanced ability to make crucial decisions about predatory threats (McComb, *et al.*, 2011). So, they are known to serve as repositories of social and ecological knowledge (McComb, *et al.*, 2001; Archie & Chiyo, 2012).

3.1.2. Home range and range behaviour

Home range can be defined as the area used by an elephant or group of elephants annually in its natural habitat (Kahl & Santiapillai, 2004; Alfred, *et al.*, 2012). Studies of African and Asian elephants in landscapes of largely open habitats have indicated that the area over which an elephant travels depends on the availability of resources, notably water, food, mates, seasonal changes, habitat loss and the man-made barriers (Schulte, 2006; Alfred, et al., 2012).

Water can be one of the most important determinants of home range size, primarily in areas where water availability can be limiting. Water also affects the amount and quality of forage, and consequently affecting the elephants' movements (Osborn, 2004; Schulte, 2006).

Elephants that live in arid environments with limited food and water may move over vast areas, while elephants in areas with artificial supply of water may live in small and stable home ranges. Associated with water and food is usually the reproductive receptivity, which is also going to affect their home range (Ntumi, et al., 2005; Schulte, 2006).

However, nowadays, the loss and fragmentation of habitat has a greatly influence in the home range than any other singer variable, reducing the available elephant habitat (Schulte, 2006; Alfred, et al., 2012).

The median herd home range size is in average, and considering an amount of studies, 113 Km^2 (range 30-799.5 Km^2) for Asian herd and 1975,7 Km^2 (range 100-5527 Km^2) for African herds. For adult bull elephants the median range size was 246,3 Km^2 for Asian and 175 Km^2 for African (Thouless & Dyer, 1992; Damiba & Ables, 1994; Jachmann, 1995; Thouless C. R., 1996; Tchamba, 1998; Thouless C. R., 1998; Douglas-Hamilton, 1998; Clubb & Mason, 2002).

In the wild, African elephants currently occur in 37 sub-Saharan African Countries. They are mainly concentrated in Central Africa. Asian elephants still occur in isolated populations in 13 countries of Asia (Figure 7).

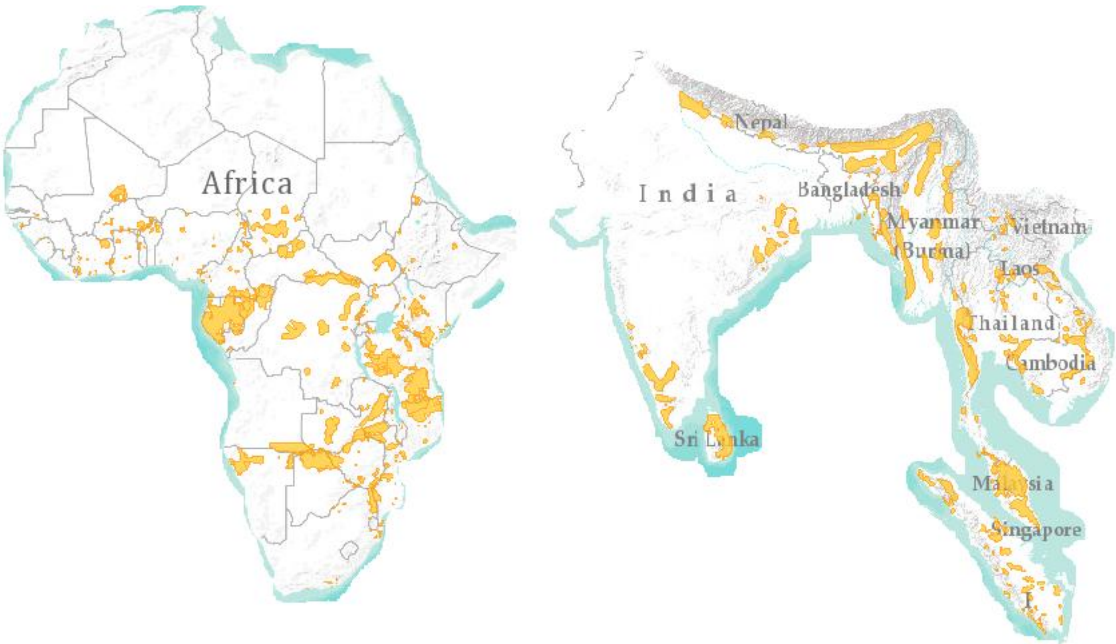


Figure 7 - Home Range of wild African elephant and wild Asian elephant. Adapted from http://maps.iucnredlist.org/map.html?id=12392 and http://maps.iucnredlist.org/map.html?id=7140

3.1.3. Communication

Elephants communicate using all their senses – hearing, vision, taste, smell and touch.

They can communicate in short distances through vocalizations, chemical signals, visual and tactile displays, and in long-distances via infrasonic vocalizations, chemical signals and seismic communication (Langbauer, 2000).

Acoustic communication is used in short and long distance contact, conflict, excitement, threat display, nervousness, advertisement for hormonal state in both sexes, group cohesion and coordination, and in greeting family or bond group members (Langbauer, 2000; Vidya & Sukumar, 2005 A; Soltis, 2010). There is no accordance on how many different vocal calls are in elephants. The most recent paper on African Elephant vocal repertoire considers a total of nine vocal call types (Soltis, 2010). Grunts and barks appear to be limited only to immature elephants, whereas revs, croaks, and chuffs were limited to adults. Rumbles, trumpets, snorts, and roars occur in any age (Soltis, 2010). Asian elephants also produce chirps (multiple short squeaks) (Langbauer, 2000).

In both species, most of it consists of very low frequency sounds known as rumbles (infrasonic), produced by the vibrating vocal folds (Langbauer, 2000; Vidya & Sukumar, 2005 A; Soltis, 2010). These signals may be used to communicate with members of the family group or to maintain contact with families of the same bond group or clan, synchronize ranging patterns and to attracts mates over long distances, as adult males and females are often spatially separated and females are in estrus for only short periods of time, so both sexes may benefit from this mechanism (Vidya & Sukumar, 2005 A; Soltis, 2010).

Chemical communication is widespread among elephants, and chemical signals are carried in urine, faeces, temporal gland secretion, saliva and interdigital Meibomian glands, and detected by olfactory sniffing and flehmen behaviour. Flehmen is when the male touches the sample with the tip of the trunk and then places the trunk in the anterior portion of the hard palate, where the paired openings of the vomeronasal organ ducts are. (Langbauer, 2000; Vidya & Sukumar, 2005 A).

The role of chemical communication can be divided into three contexts: advertisement of physical state, kin and individual recognition and long-distance communication. Urine is the mirror of the current hormonal condition in both sexes. The temporal gland secretion (TGS) is also one chemical compound that shows the physical state of musth in males. Elephants will flehmen more often urine of females in estrus and males in musth than the others with non-reproductive states. The same happens in offspring, as they flehmen more times the urine of their mothers than others, even when apart for long periods. Also, it's hypothesized that bulls may use such kin recognition to help prevent inbreeding (Langbauer, 2000; Archie, *et al.*, 2007).

Elephants of both species exhibit a lot of visual displays. In these displays different combinations of head, ear, eye, trunk, tail, body, feet, and postures, are used during play behaviour, aggression (charge and retreat behaviour) and during greeting (Vidya & Sukumar, 2005 A).

Tactile communication is used in social context to exhibit reassurance, affection and affiliation, exploration, aggression, and play. The trunk is used extensively as it is placed in another elephant's mouth during reassurance, and on the ears, mouth, eyes, tail, and body, while greeting family members. Beside the trunk, elephants also use their bodies to rub against one another in greeting, while socializing, and during play. This type of communication is also important in mother–calf interactions, probably as a means of obtaining information on the state of well-being of the calf (Langbauer, 2000; Vidya & Sukumar, 2005 A).

Low-frequency sounds generally propagate more easily than do high-frequency sounds, which are more susceptible to obstructive forces such as absorption. As such, it has been expected that low-frequency rumble vocalizations could be used in long-distance communication, as they also propagate through the ground as seismic waves (Weissengruber, *et al.*, 2006; O'Connell-Rodwell, 2007; Soltis, 2010; Plotnik, *et al.*, 2014). The ability to detect seismic waves may provide elephants with an increased range of communication in dense forests, with distant herd members, the improvement of the advertising of their hormonal state, the ability to detect underground water sources, the footfalls of other elephants or environmentally generated seismic activity (Weissengruber, *et al.*, 2006; O'Connell-Rodwell, 2007). African elephants are known to displays certain non-random "listening" behaviours and postures when responding to specific seismic cues. They cease their normal activity to adopt a motionless, 'freezing' posture, scanning the horizon, shifting positions and placing more weight on their larger front feet. This combination would suggest that elephants were employing a bone conducted pathway for seismic signal detection (Weissengruber, *et al.*, 2006; O'Connell-Rodwell, 2007).

3.1.4. Play

After weaning, which occur around two years of age, males become less dependent on their mother and increase their level of interaction, such as play, with same age conspecifics (Bagley, 2004).

Play behaviour is extremely tactile, and gender differences are observed, as males tend to play more than females, engaging in head sparring, mounting, charging, shoving, and chasing with peers of similar age and sometimes less familiar, as females play with much younger individuals and more familiar ones, playing, chasing and running games and sometimes "attacking" imaginary enemies (Vidya & Sukumar, 2005 A).

In males, this social interaction prepares them for dispersal from a female-dominated society to a male-male competitive environment (Bagley, 2004).

3.1.5. Dominance

Female's dominance can occur within the family group and between groups. In the same family group competition may occur, probably because some resources that are critical for elephants are rare, including water, mineral resources, rubbing posts or high-quality foods. Cognitive abilities and high risk of injury in contests enhance winner and loser effects, facilitating the formation of transitive dominance relationships, and so, larger females consistently dominate smaller, younger females. Dominance relations among the matriarchs of different social groups are primarily age based, rather than driven by physical or group size (Archie, *et al.*, 2006; Wittemyer & Getz, 2007).

The dominance hierarchy in male elephants is based on age and size where older, larger males outrank younger and smaller males (Archie & Chiyo, 2012). However, when they are in musth, they show increases in fighting with other elephants, especially toward other males, for frequent dominance displays (Rasmussen & Schulte, 1998; Ganswindt, *et al.*, 2005 A; Yon, *et al.*, 2008).

Males in musth are dominant to all the other nonmusth males, inclusive older and larger ones, who tend to avoid them. So, when to approximately equal-sized males in musth meet, they have aggressive contests that usually lead to severe injuries or death (Rasmussen & Schulte, 1998; Schulte, 2006).

Male elephants start establishing themselves in the dominance hierarchy when they are adolescents. Adolescence is an intense period of learning and development as they interact with new elephants and explore new areas. Therefore, by establishing themselves when adolescent, males can dedicate more time to feeding, increasing the rate of growth and avoiding dangerous conflict. Sparring is the most common behaviour demonstrated by males when they fight. It occurs most often between males of a similar age, with comparable skill to establish and reinforce the hierarchy that dominates such male societies. This behaviour rate declined with age, which is indicative of the establishment in the social hierarchy and the ritualism of male-male competition (Bagley, 2004).

3.2. Individual Behaviour

3.2.1. Basic Behaviour

We will describe as basic behaviours some aspects of urination and defecation, feeding, locomotion, resting and “cooling down”.

Observations show that elephants generally defecate on the average of every one to 4 hours or approximately 18 to 20 times per day, and urinate between 5 to 10 times per day (McKay, 1973; Lehnhardt, 2006).

Elephants have a very extensive diet as they live in a variety of habitats (Schulte, 2006). African elephants’ diet is composed mainly of grasses in the wet season, although they also feed on leaves, bark, twigs, herbs, roots, flowers and fruits. Asian elephants have a very similar diet, as they also feed on a wide variety of grasses, as well as bark, roots, leaves and small stems. So, a large portion of both species' diet consists of low quality vegetation, and therefore, a considerable part of their time (60-80% of waking hours) must be spent feeding in order to fulfill their nutritional requirements. Daily, they usually consume between 150 – 300 Kg (wet weight) of food (Clubb & Mason, 2002).

In feeding, the elephant uses mainly the trunk, especially the terminal portion, although there may be varying amounts of usage of the feet and mouth to help reducing food to a suitable size (McKay, 1973).

The elephant is capable of moving either extremely slowly or quite rapidly but they only have one gait, the walk, so unlike a horse, it can neither trot nor gallop. Still, using the walking footfall pattern, elephants can "run" quite quickly (McKay, 1973; Phuangkum, *et al.*, 2005).

On a daily basis, an Asian family herd travels an average of 3,2 Km per day (1 - 9 Km), while African elephants' family group's travels an average of 12 Km (3,8 – 7,5 Km). The Asian bulls travel similar distances (3,6 Km) but with a larger range (1 – 14,4 Km). When in Musth, they cover an average distance of 8,9 Km (2,8 – 15 Km) each day. African adult bulls ranges over 9,5 Km (preliminary findings) (Clubb & Mason, 2002).

Heat dissipation can be a problem in elephants considering their large size. Flapping their ears is the primary method they have to reduce heat. However, they can use a lot of others behavioural mechanisms, as dust and mud baths to cool down and even hide in the shades. Indeed, Rees reported that Asian elephants spent dust bathing once temperature exceeded approximately 13ºC, below this it was rarely observed (Rees, 2002).

The ear flapping increases when there is a decrease in cloud cover or in the wind, due to the fact that both would tend to increase the stress of heat on an animal standing in the open (McKay, 1973).

In the wild, adult elephants usually rest in a standing position by either standing free or touching some object such as a rock or a tree. If the animal is standing free, he generally spends most of the rest period standing on all four members with the tip of the trunk resting on the ground (McKay, 1973).

3.2.2. Body care

Elephants have a range of different behavioural mechanisms to protect their body from insect bites and from radiation (with mud bath and dust), and for skin care (Rees, 2002).

Elephants care for their skin by bathing regularly, coating it with mud and dust, and rubbing off the excess skin against trees and rocks. Besides rubbing themselves against objects, they will also use their own trunk, tail to rub various parts of the body and the feet may also be used to rub the contralateral one (McKay, 1973; Lehnhardt, 2006).

Besides body care, some of these rituals, as water baths and dusting, are also a social activity and it may be important in the cohesion of elephant groups (Rees, 2002).

3.2.3. Reproductive Behaviour

3.2.3.1. Oestrus behaviour – Females

Elephants have a poligynous mating system (Rasmussen & Schulte, 1998; Vidya & Sukumar, 2005 A; Bagley, *et al.*, 2006; Hildebrandt, *et al.*, 2011). Females can mate with more than one male during an oestrous cycle (Rasmussen & Schulte, 1998; Schulte, 2006). However, this mating system is unlikely to occur due to the presence of the dominant male (Hildebrandt, *et al.*, 2011).

They are considered to be non-seasonal, polyestrous breeders. Still, the discussion of seasonality has been challenged, because conception rates and births were reported to mainly occur in the rainy season when resources are abundant. However, under good conditions elephants can breed through the whole year (Rasmussen & Schulte, 1998; Hildebrandt, *et al.*, 2011).

Females generally reach maturity at an age of 10–12 years (Rasmussen & Schulte, 1998; Hildebrandt, *et al.*, 2011). They usually have their first calf between 10–16 years of age, and a single baby is born after a 22 months pregnancy. They provide sole care for offspring of each sex during their 10–15-year until they reach sexual maturity in females, or dispersal in males (Rasmussen & Schulte, 1998; Schulte, 2006).

Elephants have the longest oestrous of any other non-seasonal mammal. It has 13–18 weeks in length with the two phases, the luteal (6 to 12 weeks) and the follicular (4 to 6 weeks), suggesting that females may express three to four fertile cycles per year. Wild animals, however, are either pregnant or in lactational anestrus, as females are unlikily to end a receptive period without mating (Rasmussen & Schulte, 1998; Hildebrandt, *et al.*, 2011).

Elephants have an unique characteristic, where the follicular phase is concluded by two, precisely spaced and timed, LH surges (Vidya & Sukumar, 2005 A; Bagley, *et al.*, 2006; Yon, *et al.*, 2008; Hildebrandt, *et al.*, 2011). The first surge is often defined as anovulatory LH (anLH) and the second as ovulatory LH (ovLH). There might be an evolutionary purpose for the two follicular waves and precisely timed LH surges. Given the long distances bulls have to travel in search of oestrous females in the wild, it would be beneficial for females to announce impending fertility (Brown, 2006).

Female elephants sometimes exhibit a "false behavioural oestrus" several weeks before true oestrus, which may be related to excretion of a urinary pheromone. In Asian females the pheromone is identified as (Z)-7- dodecenyl acetate (Z7-12:Ac), and its concentrations increase in conjunction with the first follicular wave, although the peak levels are not attained until the ovLH surge (Bagley, *et al.*, 2006; Brown, 2006). Only in 2006 was confirmed that African elephants also release an oestrous pheromone in the urine (not the same as the Asian) (Bagley, *et al.*, 2006). Therefore, pheromones in the urine seem to play an important role in signalling an approaching oestrus, inducing flehmen response in bulls (Hildebrandt, *et al.*, 2011).

Based on behavioural studies, oestrus is estimated to last about 4 to 5 days. A receptive period of 2 to 3 days was recorded in captivity and multiple copulations are usually observed during three consecutive days (Hildebrandt, *et al.*, 2006; Hildebrandt, *et al.*, 2011).

Females announce their reproductive state through visual, auditory and chemical signs, increasing the chance of having more than one male available (Rasmussen & Schulte, 1998; Vidya & Sukumar, 2005 A).

Behaviours indicative of oestrus in females include walking away briskly from its herd in an arc-shaped trail with its head tilted to the side, known as "oestrous walk", produce deep roaring sounds and flick their tail against the vulva and then lift and hold it in the air for a while. Since the tail hairs carry urine and mucus, the tail-flicking behaviour also seems to serve as an olfactory signal to other females in the group about impending oestrus to either synchronize receptivity or suppress the reproductive activity of subdominant females during lean times. Mucus dropping and the reddening of the clitoris (which may appear through the vestibular opening when the female is urinating or simply relaxed) are other indications of oestrus in females. The quantity of mucus in the vagina increases markedly in the follicular phase, and between the first and second wave of LH it dissolves and it's mixed with urine, attracting breeding bulls (Vidya & Sukumar, 2005 A; Schulte, 2006; Hildebrandt, et al., 2011).

When chased, the females may first run away but they will eventually back up towards the bull and accept his mounting. Vocalizations may be observed during or after copulation and they are produced probably to attract additional males and set up a competition between males so that high-ranking males are accessible (Vidya & Sukumar, 2005 A; Hildebrandt, *et al.*, 2011).

Most of signs are related to social interactions, so they might be difficult to discern in captive situations because the social group structure are not preserved in most of the cases (Hildebrandt, *et al.*, 2011).

3.2.3.2. Musth - Males

Males, as previously said, leave their natal families once they reach puberty, around 12 to 15 years of age, as young teenagers to join bachelor herds or to travel alone, except during sexually active periods, when they join with females to mate. Although they are physically capable to mate females at that age, the competitions with older and larger males and the sexual preferences of the female elephants make this almost impossible to occur (Rasmussen & Schulte, 1998; Ganswindt, et al., 2005; Schulte, 2006).

In these sexually active periods, some individuals enter into a state known as musth (Ganswindt, *et al.*, 2005; Ghosal, *et al.*, 2013). It is an annual phenomenon that occurs in bulls in both genera and involves physical, physiological and behavioural changes (Rasmussen & Schulte, 1998; Schulte, 2006; Yon, et al., 2008).

It was discovered that young teenager Asian elephant males go through a "moda musth", releasing honey-like odours from their temporal gland secretions, while older males release malodorous secretions. These younger males seem to avoid conflict, as older males ignore the mellifluous odours and do not consider them a threat. The young African elephants may exhibit a similar condition (Vidya & Sukumar, 2005 A; Schulte, 2006).

Musth is associated with the significantly increase of concentrations of androgens, mainly the testosterone. They became extremely aggressive, evident by the raised head, extended ears and forward motion (Rasmussen & Schulte, 1998; Ganswindt, *et al.*, 2005; Yon, *et al.*, 2008; Ghosal, *et al.*, 2013; Kumar, *et al.*, 2014).

They increase their mobility, travelling long distances (may promote outbreeding) and spend less time feeding and resting so they can locate and associate with female in oestrus (Rasmussen & Schulte, 1998; Ganswindt, *et al.*, 2005 A; Kumar, *et al.*, 2014).

Also, they show continuous discharge of odoriferous urine and secretions of fluids from their swollen temporal glands. In African elephants both sexes can secrete a very watery fluid from the temporal glands when they are excited or stressed. This characteristic made it harder to discover musth in the African elephants, however, the males' secretion changes markedly. The fluid becomes viscous and similar to the temporal secretions in Asian bulls during musth. The female Asian elephants rarely secrete from their temporal glands, and males only secrete during musth (Rasmussen & Schulte, 1998; Ganswindt, *et al.*, 2005; Ghosal, *et al.*, 2013; Kumar, *et al.*, 2014).

Although males do not need to be in musth to mate, oestrus females prefer males who are, even if they are smaller than the nonmusth males. So, clearly, males in musth are physiologically different from nonmusth males (Rasmussen & Schulte, 1998; Ganswindt, et al., 2005; Schulte, 2006; Yon, et al., 2008).

Asian female elephants can distinguish males in musth due to chemicals present in their urines, such as cyclohexane. African female elephants also show great interest in musth urine, when comparing to non musth ones (Rasmussen & Schulte, 1998; Vidya & Sukumar, 2005 A).

The most important aspect of the reproductive behaviour for a male elephant is to locate oestrus females, and the pheromones in urine play an important role, as previously stated. When a bull approaches a herd he typically inspects each genitals, fresh feces, and urine deposits of each female, even very young ones with his trunk, showing great interest in females in oestrus. Most females remain still and they often backs into the males and urinate prior to or just following this contact, and the male consequently investigates their urine (Rasmussen & Schulte, 1998; Bagley, et al., 2006; Schulte, 2006; Hildebrandt, et al., 2011).

If the female is sexually receptive the male exhibits a series of behaviours, such as sniff, check, place and a flehmen response. A sniff is when the male hover his nasal openings over a sample, without contact. Check is when he touches the sample only using the trunk tip finger(s) and place is when the entire end of the trunk is placed onto sample. However, not all sniffs lead to checks or places, and they not all result in a flehmen. The rate of flehmen responses increases as the ovulation approaches, and premating behaviours are observed as penile erections and mountings (Rasmussen & Schulte, 1998; Bagley, et al., 2006; Schulte, 2006; Hildebrandt, et al., 2011).

During courtship, the bull touches the face, eyes, ears, hindlegs and vulva of the cow with his trunk. He also raises his head and trunk to reach over her shoulder or flank before trying to mount and copulate. He will use his head and trunk to push the female forwards. If he is successful she will show signs of acceptance, for example, using her trunk to touch the penis of the bull. The bull will use his front legs to separate the hind legs of the female, mount her, and will search for and pass his penis through the female vulva (Perera, 2014). The cooperation of the female is mandatory for a successful intromission, because even if the male may use his trunk to position or hold the female, she needs to stand still to allow intromission of the S-shaped penis into the vulva, which is positioned ventrally, between her hind legs (Schulte, 2006; Hildebrandt, et al., 2011).

The length of musth periods is variable, but it's not related to age. Some animals in captivity are capable of showing musth-related signs at an earlier age than those in the wild, which usually enter musth at or beyond 24 years of age. This may happen because of the absence of competitors in captivity as the musth in younger free-ranging bulls can be suppressed or even prevented by the presence of older or more dominant musth bulls. It may also be possible that earlier onset of musth in captive animals might be attributed to improved nutritional status resulting from a higher availability and quality of food (Ganswindt, *et al.*, 2005 A; Ganswindt, *et al.*, 2005).

Nevertheless, it is poorly understood what triggers the onset of musth and what causes the variations in its length or even the lack of seasonality. However, recent data suggests that the initial stimulus for the musth condition it is probably the elevation of androgens in the blood stream above a certain threshold, and that TGS responds earlier and to lower androgens than UD (urine dribbling), which manifests itself later and requires a higher level of androgens. This information is relevant when dealing with bulls in captivity, because it provides an early recognition and indication that he has been primed for the latter, more aggressive state of musth, and therefore, extreme caution must be taken in consideration (Ganswindt, *et al.*, 2005 A).

4. Elephants in Captivity

Elephants have been kept in animal collections for at least 3500 years. But only in the middle of the 19th century, Zoos that would be recognizable as such today, had emerged (Csuti, 2006).

Although the opinions regarding the captivity of elephants in Zoos are very divergent, captive elephants have been extensively studied in different areas, and often the results have relevance to the conservation of the species (Csuti, 2006). Therefore, there are potential benefits for keeping elephants in Zoos, such as to enhance the knowledge of their biology through research, aiding ex situ conservation through public awareness, public education, fundraising and advocacy in support of the conservation of wild elephants and their habitats (Clubb & Mason, 2002; Riddle & Stremme, 2011).

Populations of captive elephants have been declining and this numbers may be restricted by their social needs. Taylor and Poole suggest that the key is larger herd groups and continued access between males and females (Taylor & Poole, 1998; Csuti, 2006).

As a result, improvements have been made and in this chapter it will be reviewed the most significant topics and concerns about elephants that are captive in Zoological facilities.

4.1. Social Groups

One of most critical aspect of elephant husbandry is the social structure and social needs of elephants (Lehnhardt, 2006).

As described in 3.1.1., female elephants are family animals as they spend their lives on rearing calves and interfacing with their family unit. Hence, in captivity, females should have the perfect conditions for reproduction, calf rearing, and maintenance of long-term familial relationships with their female relatives (Lehnhardt, 2006).

However, captive elephants' social structure is very different from those in the wild (Freeman, *et al.*, 2004). Groups are a lot smaller and composed of mostly unrelated individuals (birth of elephants is not common in captivity and therefore calves are rare), captive elephant herds are inclined toward females because few facilities maintain bulls and some individuals live in mixed species (African and Asian) groups, although this is becoming less common due to the desire to breed elephants in a more natural environment and because of the possibility of disease transfer between the two species (particularly the herpesvirus infections). Yet, not all these factors are true for all captive groups (Schulte B. A., 2000; Freeman, et al., 2004; Schulte, 2006).

Even if elephants in captivity do not reflect a kin-based social structure, they display many of the same behaviours as wild elephants. One of them is the matrilineal dominance, even if there is no true matriarch. Dominance status may still be important for maintaining social harmony, and it's commonly determined by size and temperament (Freeman, et al., 2004; Schulte, 2006).

Male elephants, in the other hand, have very different social needs as in the wild the adult ones spend as much as 95% of their lives alone or in loose association with other bulls (Lehnhardt, 2006). They may be housed alone, but they never should be isolated, so some interactions must be allowed, as olfactory, visual, and/or auditory interaction (AZA, 2011).

Elephant bull nature is competitive rather than affiliative, causing many challenges for captive husbandry because they don't need as much social interaction as females, but definitely need competitive challenges to express their natural urges (Lehnhardt, 2006). They experience musth in captivity, but the apparent benefits of musth may be lost as most of them remain at the same location for long periods and can neither establish dominance out of musth nor compete for selection by a female (Schulte B. A., 2000).

Therefore, elephants should be kept with family units appropriate in size and composition and with adequate space and a varied environment to maximize physical and mental welfare (Schulte, 2006). The European Association of Zoos and Aquaria (EAZA) recommends a minimum of four cows together (Terkel, 2004). Multigenerational groups are also a goal for elephants in captivity as most of their behavioural repertoire is learned, rather than innate (AZA, 2011).

4.2. Reproductive Management

Captive breeding has now become most urgent for Zoos, as sustaining the populations fully depend on animals born in captivity. The major problems regarding breeding in captivity are failure of conception and high calf mortality due to still birth and maternal infanticide (Perera, 2014).

One cause of low birth rate in Zoos is the problem of handling male aggressiveness, particularly during the musth period. Therefore, Zoos tend to keep only a few or no breeding bulls. Also, social ranking may cause poor quality semen and suppress libido. Moreover, older nulliparous females show a relatively high incidence of reproductive pathologies, appearing to be particularly susceptible, which led to speculations whether the continuous ovarian cyclicity of non-breeding females is having a negative and cumulative effect on reproductive health in captive elephants. In the wild, most females are either pregnant or lactating and they experience comparatively few reproductive cycles in their lifetime. Parturition disorders become more frequent requiring further research in order to develop more effective treatment solutions, and aged cows may exhibit irregular cycling or no cycling at all (Hildebrandt, *et al.*, 2006; Perera, 2014).

These factors have a high impact on the fecundity rate and sustainability of the elephants' population in captivity. Nevertheless, artificial insemination (AI) is a successful breeding method in elephants as shipment of semen can help to minimize the bull-handling problems in Zoos with less contact between both sexes and help to sustain the population in a long term (Hildebrandt, *et al.*, 2006; Perera, 2014).

4.3. Husbandry

Each component of the elephants' husbandry program contributes to their overall welfare. The main goal should always be to provide the perfect environment that meets the species' needs from a social and psychological context (Lehnhardt, 2006).

4.3.1. Handling System

There are four types of different styles that are used to manage elephants in captivity: Free contact, protected contact, confined contact and no contact.

Free contact is when the elephant is handled directly sharing the same unrestricted space with the handler (Clubb & Mason, 2002; Riddle & Stremme, 2011). This type of contact is used in combination of negative reinforcement, positive reinforcement and physical punishment or threat of physical punishment for training, and they rely on the establishment of dominance over the elephant (Riddle & Stremme, 2011). Protected contact is handling an elephant without sharing the same unrestricted space. Usually the handler has contact with the animal through protective barriers and the elephant is not confined. Unlike the free contact, this method uses positive reinforcement training with the elephant's voluntary cooperation. The system is intended to allow the same health and veterinary access to elephants as does free contact, with improved safety for keepers and other personal involved (Clubb & Mason, 2002; Harris, *et al.*, 2008; Riddle & Stremme, 2011). Confined contact is a protect contact but the elephant is spatially confined (Clubb & Mason, 2002). No contact is when the handler as no contact with the animals, unless they are chemical sedated (Clubb & Mason, 2002).

4.3.2. Physical Environment

Indoors facilities must provide the adequate space for animals to move and lie down without any restriction (AZA, 2011).

The EAZA recommends that the indoor sizes for boxes should be 50 m^2 for both sexes, and the total indoor area should be 150 m^2 for three cows with extra 50 m^2 for each extra cow (Clubb & Mason, 2002; Terkel, 2004).

The minimum temperature should be 15°C (optimal 20°C). Regarding the floor, EAZA states that it should be rapid drying, insulated and well drained (Terkel, 2004).

Outdoor habitats have to provide the sufficient space and environmental complexity to allow natural behaviour and social interactions (AZA, 2011). Taking this into account, the EAZA recommends a size of 2000 m^2 for eight cows and 500 m^2 for bulls (Terkel, 2004).

EAZA also recommends the use of natural substrate (sand, soil and grasse) to allow dust bathing.

The existence of a pool (2 x 3,5 x 1 m deep) and objects for them to rub (rocks or tree stumps) in indoor and outdoor enclosures is also fundamental so they can manifest natural behaviours of body care and socialization (Clubb & Mason, 2002).

The time spent outdoor varies considerably between Zoos. It depends on the climate, on the daily management and on the enclosure design. However, it is stated that elephants should have access to the outdoor area for as much as possible, so access should be given over a 24 hour period (Clubb & Mason, 2002; Terkel, 2004).

4.4. Diet

Proper diet and nutrition are basic to good husbandry. In the wild, elephants forage for many hours each day. They have low digestibility of plant materials due to the fact that their transit has significantly fast passage rates, they consume highly fibrous food that may be high in lignin, they don't masticate food properly and their stomach and intestinal movements may not be strong enough to macerate the food sufficiently. So, for all these reasons they have to eat large quantities of food (Lehnhardt, 2006; Silva-Fletcher, 2014).

It is very common to see overweight elephants in captivity and almost never in the wild. In their natural habitats, they go through times of nutritional stress during the dry seasons and in captivity, they are provided with relatively consistent food source all year around. So, it's fundamental that their diet is very balanced from a caloric perspective because excess fat may have significant impact on the overall health and well being of elephants, such as conception, parturition and leg and foot problems (Lehnhardt, 2006; Morfeld, *et al*., 2014).

In the wild, during wet season elephants are preferential grazers when sedges and grasses have high content of protein, and in dry season they become more browsers when the protein content of grass decreases. However, Taylor and Poole's survey showed that 90% of European elephant enclosures did not provide an opportunity to graze (Taylor & Poole, 1998; Clubb & Mason, 2002).

Usually the diet in a Zoo consists mainly in dried forage (hay most of the times), pellets, small amount of fruit and vegetables, branches and leaves to browse and vitamin and minerals supplement. The difference between the Zoos is related to the frequency and manner in which this food is provided (Clubb & Mason, 2002).

Browse is a great way to improve elephants' activity because it requires a greater manipulation to ingest and thus also works as enrichment (Lehnhardt, 2006).

4.5. Elephant Care

Each elephant kept in a Zoological facility must be visually inspected on a daily basis.

The Association of Zoos and Aquariums states that foot and skin care must be provided by the elephant keepers and the elephant must be trained to accept that care (AZA, 2011).

Elephants should be free of foot injuries and diseases. Usually, elephant's feet should be cleaned and inspected daily, and if they are in good condition only periodic pad and nail trimming is necessary (AZA, 2011).

Skin must also be cared for as needed through bathing, removal of dead skin and treatment of dry skin or other skin problems. It must be inspected thoroughly on a daily basis as well (AZA, 2011).

4.6. Welfare

The study on animal welfare is one of the most complex subjects, because there is rarely an agreement as to which the best indicators of welfare are and which should be measured. In Zoological animals is even more difficult to assess because they can be difficult to observe closely or to inspect (Harris, *et al.*, 2008).

The major problem is to decide what "animal welfare" really means. To different researchers it means different things. So, the exact way in which scientists define welfare will influence the types of measure to assess it objectively (Mason & Mendll, 1993).

Nevertheless, welfare is related to the animal affective state, "what it feels". Good welfare is, for that reason, when the animal experiences positive emotional states and the opposite is poor welfare, which we cannot measure directly, but can infer from certain behavioural and cognitive responses, physiological responses, and effects on reproduction and health (Dawkins, 1990; Mason & Veasey, 2010 A).

In 2008, a report on elephant welfare in UK Zoos considered behaviour and physical health as the most important indicators of welfare, although they also focused on faecal cortisol metabolites (FCM), locomotion score and body condition score. About the factors likely to lead to good and poor welfare it included a variety of factors related to elephants' physical and social environment, housing and husbandry. Behaviour provides information regarding the animals' needs, preferences and internal states. Thus, a careful observation and interpretation of normal (e.g. eating, drinking, social behaviour, sleeping) and any abnormal behaviour (e.g. excessive aggression, stereotypes) can be used to gain a good overall picture of the welfare. Physical health in another hand is different and the results must be carefully analysed, as good health does not necessarily equal good welfare and ill-health is very often linked with poor welfare. The animal, however, may need to experience a clinical sign, as pain, to be impaired by illness or injury and for this reason, researchers using physical health as an indicator generally do it in combination with other measures (as behaviour for example) (Harris, *et al.*, 2008).

In a 2013 study, it was emphasized that not only the absence of poor welfare should be analysed but also the presence of good welfare such the physical well being and comfort (feeding and avoiding obesity, freedom of movement to seek physical comfort and optimal health) engagement with the environment (species-appropriate social behaviours, species-appropriate nonsocial behaviours and good human-elephant relationships) and positive psychological state (avoidance of negative emotions as fear, frustration, apathy and experience of positive emotions, as security and contentment) (Carlstead, *et al.*, 2013).

4.6.1. Stereotypic Behaviour

Stereotypes are defined as unvarying and repetitive behaviours with no obvious goal or function, most often observed in animals that are confined, constraining their ability to perform certain behaviours (Ödberg, 1978; Mason, 1991; Harris, et al., 2008). They have a wide range of origins and proximate causes as some can occur when an animal is consistently unable to reach a particular goal by performing appetitive behaviour, others when they are unable to reach a desired place or even when they are unable escape from disturbance (Rees, 2004).

There are three possible reasons that may be the cause for their repetitive nature. The first involves the recurrent stimuli in the animal's internal or external environment, the second reward and reinforcement (e.g. 'coping') and the third, perseveration or its correlates (Mason, 2006).

The first explanation for the repeatability is the existence of factors, as internal states induced by the captive environment (such as frustration), and/or cues external to the animal, which trigger or motivate a specific behavioural response. When the behavioural responses to the stimuli do not extinguish nor habituate (i. e., the animal continues to demonstrate the same behaviour to a certain stimuli, regardless how many times he was exposed to it), suggest that they are reinforced, continuing because of correlations between their performance and some positive outcome (Mason, 2006).

The second explanation is the reward and reinforcement of these behaviours despite them seeming functionless (Mason, 2006). For example, bouts of self injurious biting in primates, despite it arises from adverse life events, are correlated with reductions in physiological stress, thus helping to reduce anxiety (Novak, *et al.*, 2006). Yet, there is no evidence that all stereotypes help animals to cope or that a single mechanism, as the stress reduction, is always involved (Mason, 2006).

The last explanation is the behavioural disinhibition, as manifested in the persistence of it. In other words, the generalized tendency to inappropriately repeat recently performed behaviours. This tendencies vary natural between normal individuals, change with age, increase with acute stress and with early social deprivation. The environment also creates a state of sustained stress which is going to affect how the cortical-basal ganglia loops elicit and sequence behaviour, resulting in abnormal behavioural desinhibition (Mason, 2006).

In fact, Mason redefined stereotypic behaviours as ''repetitive behaviours induced by frustration, repeated attempts to cope, and/or central nervous system (brain) dysfunction'', distinguishing them from repetitive behaviours that do not indicate poor welfare, as a cat kneading a comfortable lap, or a dog circling before settling to sleep (Mason, 2006; Mason, et al., 2007; Mason & Veasey, 2010 A).

Stereotypic behaviour is common in Zoos and has been used in welfare assessment for two reasons. First, it is often originated from intention movements and other behavioural signs of frustrated motivation. Second, is most evident in environments that induce other signs of poor well-being (Mason, *et al.*, 2007; Mason & Veasey, 2010 A).

However, one must be very careful when using stereotypic behaviour to infer well-being. They may indicate past problems (Zoo elephants originating from circuses are particularly prone to this behaviour) rather than current ones, and animals with negligible stereotypic behaviour may have poorer welfare, because they can be apathetic or immobile due to pain, than animals with high levels of it (Harris, *et al.*, 2008; Mason & Veasey, 2010 A).

The conditions for many elephants in captivity are sub-optimal or at least have been historically as the prevalent stereotypic behaviour across Zoo populations suggests (Mason & Veasey, 2010 B).

In elephants held in Zoos, stereotypic behaviours are typically fore- and back-steps accompanied by body and trunk swaying in forwards and backwards, swaying/weaving, head-nodding, and sometimes pacing (Kurt & Garai, 2001; Harris, *et al.*, 2008; Mason & Veasey, 2010 A).

Although weaving in captive elephants is a well known phenomenon, neither the ontogeny of weaving nor the external stimuli leading to the stereotypy were described so far, because it is very difficult to study the aethology of stereotypic behaviour in these animals due to their longevity and the fact that most have been moved from Zoo to Zoo, taking their stereotypes with them (Kurt & Garai, 2001; Rees, 2004).

Stereotypic behaviour can be tackled in five potentials ways: through genetic selection, pharmacological treatment, reinforcement of alternative behaviours, punishment and environmental enrichment. All of them, except punishment, have potentials roles to play but enrichment is the preferred approach because it is most likely to tackle the problems underlying stereotypic behaviours, and thence to improve both welfare and behaviour with few unwanted side-effects (Mason, *et al.*, 2007).

4.7. Environmental Enrichment

Environmental enrichment is a concept which describes how the environments of captive animals can be changed for their own benefit. Therefore, it is a process for improving or enhancing Zoo animal environments and care within the context of their inhabitants' behavioural biology and natural history. So, changes to structures and husbandry practices are made with the goal of increasing behavioural choices to animals, thus enhancing animal welfare (Young, 2003).

There are few main goals when implementing environmental enrichment. It should increase behavioural diversity, reduce the frequencies of abnormal behaviour, increase the range or number of normal behaviour patterns, increase positive utilization of the environment and the ability to cope with challenges in a more normal way (Young, 2003).

There are five majors' types of enrichment: social, occupational, physical, sensory and nutritional, as described by Young (2003).

4.7.1. Social

Social enrichment can be through contact or non contact. Contact can be between conspecifics (individuals of the same species) or with contraspecifics (individuals from different species). Non contact is made through visual, auditory or co-operative device (Young, 2003).

4.7.2. Occupational

The occupational enrichment can be made through physiological stimulation, with the use of puzzles for example, and through exercise (Young, 2003).

AZA states that daily exercise is another important component in the elephant husbandry. However, there is no current data to indicate what amount of activity, or what daily walking distance is most appropriate for optimal elephant welfare. The basic needs may be different for each elephant (AZA, 2011).

Training is very important in these animals and it is considered as exercise enrichment.

4.7.3. Physical

The physical environment is related to the animal's enclosure (size and complexity) and to the accessorises (e.g. furniture, toys, ropes) (Young, 2003).

4.7.4. Sensory

The sensory enrichment, as the name implies, involves all the senses. Visual, auditory, olfactory, tactile and taste stimulation (Young, 2003).

4.7.5. Nutritional

The food and foraging enrichment is another very import for elephants, as they spend most of their time searching for food, and eating.

There a lot of things that can be made to in terms of nutritional enrichment considering elephants' behaviour. Scatter food about the enclosure, hide food in devices (e.g. pipes, balls, tyres), provide logs for bark and branches to browse are some of them (Young, 2003).

Overall, good enrichment offers animals opportunities to perform activities that they prefer over stereotypic behaviours by reducing underlying frustrations and contributory stress levels, and/or simply by taking up time with preferred behaviours. Furthermore, it gives the animal the choice to whether or not to participate in the "treatment" (unlike the others ways to tackle stereotypic behaviour, as physical prevention, or pharmacological approaches) (Mason, *et al.*, 2007).

In practice, however, it is unknown how successful environmental enrichment acts, and it never seems to “work” 100% suggesting either that the enrichments being used are never quite optimal, or that by the time they are tackled, stereotypic behaviours have become resistant to change (Mason, *et al.*, 2007).

Consequently, Mason suggests that enrichments effectiveness could perhaps be enhanced via the positive reinforcement of non-stereotypic behaviours (or even, in the future, with pharmacological compounds such as anxiolytics, although not without considerably more background information than exists at present) (Mason, *et al.*, 2007).

II. Aims

The main objective of this work is to compare in different Zoos populations the effect of different environmental variables in elephant's behaviour.

As more specifics aims:

1. Analyse the female behaviours in the presence and absence of the male;
2. Analyse the different conditions that influence the foraging and locomotion behaviour;
3. Study the effect of environmental temperature in ears' flapping and dusting behaviours;
4. Relate the production of vocalizations with the different populations and with specific variables, such as presence of the male and aggression behaviours;
5. Correlate rub behaviour with dusting and mudding;
6. Relate play behaviour with enrichment programs;
7. Find the "triggers" of stereotypic behaviours at Zoo 1.

III. Materials and Methods

1. Collection site

1.1. Zoo 1

1.1.1. Enclosure

The elephant's exhibit in Zoo 1 is very recent. The elephants were transferred from the former exhibit to the current one in 2008.

The house has two large domes resulting in a great amount of daylight in the stables and two separated areas for males and females. Males are not housed together and therefore they both have their own indoor and outdoor facility (Table 3).

Table 3 - Different exhibit's area at Zoo 1

Indoor	Females	748.1 m2
	Male 1	127 m2
	Male 2	125.3 m2
Outdoor	Females	2348 m2
	Male 1	528.6 m2
	Male 2	412.8 m2
Visitors' area indoor		950 m2
Technique and service		770 m2

In the indoor space the walls and the floor are composed by hard concrete, but for the wellbeing of the elephants the floors were filled with half a meter of soft sand. The glass roofs allow the solar energy to be accumulated in walls and floors (Figure 8). All of these conditions turn this into an eco-friendly building.

Figure 8 - Females' Indoor facility at Zoo 1

There are training boxes in the backstage in order to allow the keepers and veterinarians to be able to train, check and nurse the elephants.

The outdoor facility has sand floors, a deep water pool, rocks for them to rub and a lot of enrichment devices (Figure 9 and 10).

Figure 9 - Females' Outdoor Facility at Zoo 1

Figure 10 - Females' Outdoor Facility - Water pool, at Zoo 1

1.1.2. Husbandry

At Zoo 1 the elephant care is made through protected contact. They are released daily into the outdoor facility at 10:00 until 14:30 pm. Until 13:00 they have access to both outdoor and indoor facilities, but after that time they are closed in the outdoor space until 14:30 so the keepers can clean the indoor area and prepare it with hidden food for example, so they can be entertained during the night. The females sleep all together in the indoor exhibit. The changes through seasons are in summer time where they have access to the outdoor space during the entire day.

They have hay and branches *ad libitum* through the day, but usually every couple of hours the keepers give them extra food as nutritional enrichment.

They are trained daily in the boxes for 1 hour for foot care and medical examinations.

1.1.3. Environmental Enrichment

There are a lot of enrichment devices around the facilities to keep the elephants occupied.

A lot of these devices work as nutritional enrichment, offering rewards to the animals. In the interior facilities they have hay wrapped in nets, hanging from the ceiling. Some of them are out of the elephants reach so that they have to use objects such as bulks or balls in order to get to the hay (Figure 11). Other than the suspended hay, they also own a kind of pipe with rewards inside it, in order to receive them the animal has to turn the pipe around (Figure 12). The keepers hide food on the balls and tires either indoor or in the outdoor facilities. Another nutritional enrichment used by the Zoo is hidding food (carrots, for example) under sand hills to incite the search through foraging.

Branches are provided in both exhibits.

Figure 11 - Nutritional enrichment at the Indoor space (Zoo 1)

Figure 12 - Another nutritional enrichment at the Indoor space (Zoo 1)

It's a group of seven animals, four females, a calf and two males. The males are housed apart and the females and the calf cohabit together. The Zoo is currently introducing the oldest male to the females so that they spend more time together to improve its reproductive success.

1.2. Zoo 2

1.2.1. Enclosure

The outdoor space has 2500 m2. The floor is sand that has been grassed over in some places, to be very similar to a savannah (Figure 13). There is a pool for bathing and drinking. The indoor space has two pens, with a total of 312 m^2. Both have concrete floor, but one of the pens is covered with 75cm of sand (Figure 14).

Figure 13 - Outdoor space at Zoo 2

Figure 14 - Indoor pens at Zoo 2

There is only one African elephant cow at Zoo 2. Until 2010 she was housed together with an Asian elephant cow, which had to be euthanized due to untreatable foot abscesses.

1.2.2. Husbandry

The husbandry procedure is a semi-protected contact with the elephant. Daily it's given to her linseed pellets, pony cubes, two bales of hay, mixed green vegetables and branches. She is locked in the indoor space from 5pm until 8am the next day, where then she can choose to be in one or another enclosure. In the summer she is not closed in until 7pm.

Foot care is done once a week. She is never hosed, because she hates it, and it was a careful choice to make because if they hosed her she would get really angry and become very distrusting.

1.2.3. Environmental Enrichment

In the outdoor space there are some devices to contribute for a better environmental enrichment, such swing ball, tires, bulks and boxes (Figure 15).

The entire exhibit is conceived with the appropriate conditions for the bodycare of the animals (mudbaths, dustbaths, baths, hose, rub).

Figure 15 - Environmental enrichment in the outdoor space, at Zoo 2

Her hay is keep in a metal box with a lot of holes, so she can put her trunk inside and try to get out the hay. It's a nutritional device that makes the animal work for the food, but it doesn't stimulate locomotion, leading to a certain degree of inactivity (Figure 16). Nevertheless, in the daily management, keepers provide small logs for bark stripping and large branches to her to browse. They also hide food in tires, plastic pipes and in blue containers (Figure 16) that are inside the metal boxes. The female has to move the container around so the pellets can fall on the floor. This type of nutritional enrichment is not performed as regular as the others, due to her limited eyesight.

Figure 16 - Nutritional enrichment's device in the Indoor space, at Zoo 2 (blue container).

As social enrichment she has giraffes as neighbors, but in her enclosure she is by her own, so the social enrichment is very limited.

1.3. Zoo 3

1.3.1. Enclosure

The outdoor space has a total of 24 ha. In this space there is a lot of natural enrichment, as rocks, a deep water pool, sand, mud and the floor is mainly grass, which is one of the best qualities of it, as elephants love to spend their time foraging (Figure 17).

Figure 17 - Outdoor space, Zoo 3

Each elephant is held separately (or with the respective calf) in separated boxes at the indoor space. It has also four pens, which can be used as an "outdoor" space, if an elephant needs to be kept separated from the herd.

1.3.2. Husbandry

The Zoo practices protected contact with the elephants as the husbandry procedures.

It's given to the elephants hay and pellets in the morning before they are released to the outdoor space (Figure 18). By night after they are locked in, they receive pellets and hay every day, and on Mondays and Thursdays they receive mineral salt, on Tuesdays it's molasses (so they can get used to the sweet that it's need to oral medications) and in the other days they receive fruits and vegetables. During the day they graze in the outdoor space.

Figure 18 - Indoor boxes with the morning hay, at Zoo 3.

They are locked everyday from 7pm until 10am the next day, except in the winter, when they are locked a little bit earlier due to the lack of sunlight.

There is no need for foot care as they have a lot of soil to wear out their nails and foot pads, and no need for skin care as well. However, they are trained (not regularly) for foot care, blood collection, mouth inspection and other movements so they can accept medical treatments if needed (Figure 19).

Figure 19 - Trainning at Zoo 3

1.3.3. Environmental enrichment

They don't need to have enrichment programs. Its' habitat has everything they need for them to be able to perform normal behaviours as they would in the wild. There are several rocks to rub, grass for foraging, water deep pool for baths, sand and mud to protect their body against insects and sunburns, and trees to provide shades during the day.

The only enrichment they have is the social one. They cohabit with two more species, *Bubalus bubalis* (Water buffalo) from Asia and *Kobus leche* (Lechwe) an antilope from Africa (Figure 20).

Figure 20 - *Kobus leche* and *Bubalus bubalis*.

2. Sample

Twenty-two animals were present at this study but only eighteen were statistical analysed (Table 4).

Table 4 - All the animals preset in this study. Data regarding their species, gender, age, and years in the collection

Zoo	Specie	Gender	Animal	Age	In collection since (years)
1	*Elephas maximus*	Females	F1	46	1
			F2	25	1
			F3	15	11
			F4	15	11
		Males	M1	15	11
			M2	54	51
			M3	<1	Captive born
2	*Loxodonta Africana*	Female	F5	43	36
3	*Loxodonta Africana*	Females	F6	34	24
			F7	19	Captive born
			F8	13	Captive born
			F9	31	20
			F10	11	Captive born
			F11	33	19
			F12	12	Captive born
			F13	9	Captive born
			F14	7	Captive born
			F15	2	Captive born
		Males	M4	2	Captive born
			M5	10	Captive born
			M6	17	3
			M7	13	Captive born

In Zoo 1, the behaviours of all the three males were not recorded. M1 was exclude due to the fact that he was in other facility and therefore, could not been observed. M2 was the male that was spending some time with the females every day, so his influence on females' behaviour was analysed but not his behaviour in particular. M3 was excluded because he is a calf and therefore, his behaviour is not under the influence of the environment yet.

In Zoo 3, M6 was excluded from statistical analysis due to the lack of samples as he was not spending much time with the herd.

It is very important to look carefully at each individual. All their previously histories were carefully analised and took into consideration. For example, the F1 and F2 in the Zoo 1 are females that demonstrate more stereotypic behaviour than any other in this particular study. However, they are only in that collection very recently, and therefore, their behaviour may not result from this Zoo but from previous institutions. F2 was treated with Citalopram and she received 2000mg SID PO when she got the most. The dosage was gradually increased to reach that level, and then tapered back again, when concluded that there was no real effect. At the same time, F1 received a max of 500mg naltrexone SID PO following a similar schedule.

F5 is a female with medical conditions. She has no right eye since 2011, due to a chronic glaucoma and her left one has a poor vision, although it improved since the cataract operation on the same year.

3. Methods of data collection

At each Zoo, a survey was performed with questions regarding the style of elephant care (direct contact, protected contact and off-hands), enrichment programs, difference between day and night management, seasonal aspects, how long the group members were already integrated, where did the elephants come from, age structure of the whole group, age of the single elephants and integration situation of new herd members.

Also, there were recorded videos of elephant behaviour for periods of 45 minutes, by the same observer using a Sony Cyber-shot G – 10.2 megapixels. The behaviours were analised for blocks of five minutes, therefore, in 45 minutes' footage there was 9 blocks of 5 minutes each. After each 45 minutes of data collection there was a pause of 45 minutes (10:00 to 16:00, which equals to 3 hours of data collection per day, during 7 days to each Zoo).

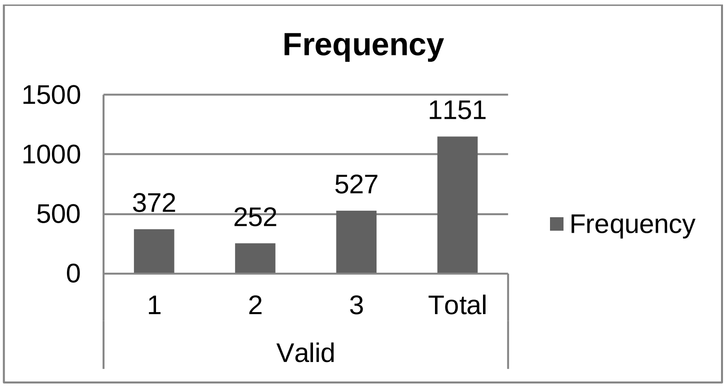
The behaviours of the elephants were divided in four main groups: the basics, the care, the social and the stereotyped behaviours (Table 5).

Table 5 - Ethogram of elephants' behaviours

Type	Behaviour	Code	Description
BASIC	Locomotion	LO	Moving forward or backward (walking or trotting)
	Elimination	EL	Defecates or urinates
	Stand	ST	Remain in the same location for at least 2”
	Feeding	FD	Foraging/Drinking
	Cooling Down	CD	Flapping or spreading ears
	Rest trunk	RT	Place approximately one-quarter of the lower trunk on the ground for at least 5”
CARE	Bath	BH	Submerse most or all of body in water
	Dust	DS	Tossing sand, dust, or dirt onto own body with trunk
	Mud	MD	Use the trunk to throw mud particles on the body or moving body rapidly in a mud hole
	Rub/Scratches	RB	Elephant rubs any body part against a surface, with objects or with any other body part
SOCIAL	Chase	CH	One elephant pursues another
	Social Affiliation	AF	Social play, trunk tangle, caressing with another elephant
	Object Play	OP	Moves, pushes, tosses, or picks up enrichment “toy” provided
	Social Aggression	AG	Attacks with trunk, mouth, legs, head but, pushing; exclude keepers
	Sparring	SP	Entwine trunks/tusks and push against another
	Beating Trunk	BT	Violently beats with the trunk on the ground, meaning anger or displeasure
	Caressing	CR	Touching head and entwine trunks together (African elephants)
	Mating	MT	Pair of elephants brought together for breeding
STEREOTYPIC	Pacing	PC	Taking three or more steps toward no obvious destination, often in circles
	Weaving	WE	Swaying from side to side or backwards and forwards
	Head bobbing	HO	Up and down or from one side to another.
	Trunk tossing	TT	Swaying of the trunk

Statistical analysis was carried out using the SPSS 17.0 statistical software (SPSS Inc. USA). First the equality of variances for each variable was tested by Levene test. Then significant differences were assessed using analysis of variance (ANOVA) followed by Bonferroni post-hoc test for multiple comparisons. Non-parametric data were computed using the χ2 test or Fisher's exact test with Bonferroni's correction. The Pearson product-moment correlation coefficient was used to evaluate the correlation (linear dependence) among different continuous variables. p values of less than 0.05 were considered to be statistically significant.

Only valid observations were statistical analysed, i.e., it was only considered a valid observation for an animal if that animal was present during the entire 5 minutes recordings (Graphic 1).



Graphic 1 - Number of valid observations within each Zoo (1, 2 and 3).

IV. Results and Discussion

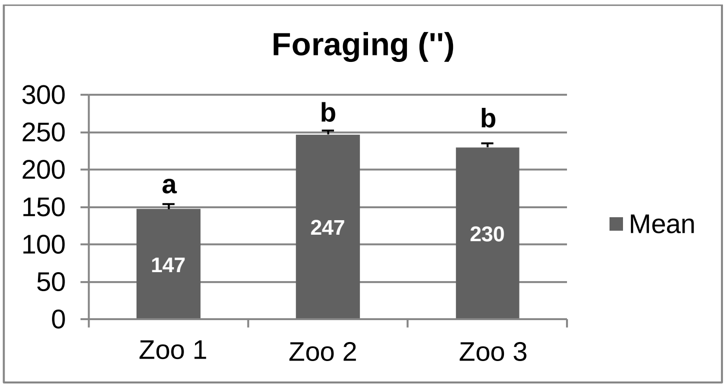
This project is intended to analyse and study the elephant behaviour in captivity. The results will be discussed as they are being presented.

1. Basic Behaviours

The basic behaviours analysed were foraging, locomotion, elimination, standing, feeding, cooling down, vocalizations and resting trunk.

1.1. Foraging Behaviour

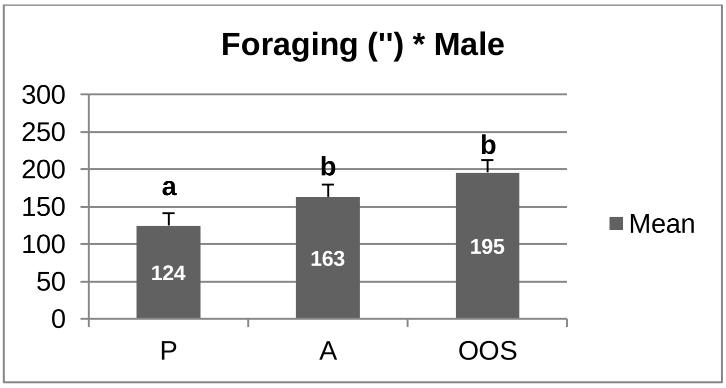
It was demonstrated with statistical significance that Zoos 2 and 3, both African elephants, spent more time foraging. Both Zoo 2 and 3 have statistically significant results when compared to Zoo 1, but not when compared with each other (Graphic 2).



Graphic 2 - Mean of number of seconds in five 5' intervals that elephants spent foraging in each Zoo. [a] Statistical significant when compared to Zoo 2 and 3 ([b]) ($p<0,05$). $N_{Zoo\ 1}= 372$; $N_{Zoo\ 2}= 252$; $N_{Zoo\ 3}= 527$

Zoo 2 and 3 spent more time foraging than Zoo 1. At Zoo 2 there is only one elephant and for that reason she spends most of her time eating because she doesn't have any social interaction or any other occupation. On the other hand, Zoo 3 has excellent foraging conditions because elephants can be constantly grazing, allowing similar behaviours as the wild ones. Taylor and Poole (1998) showed that 90% of European elephant enclosures did not provide opportunities to graze, and therefore, their foraging behaviour must be encouraged trough browse, for example, which also may help exercise the elephants.

The regular time that elephants spend foraging in the wild is usually between 60 and 80% of their awaking hours, so only Zoo 1 is below that period. It will be analysed if the presence/absence of the male elephant may have influenced this result (Graphic 3).

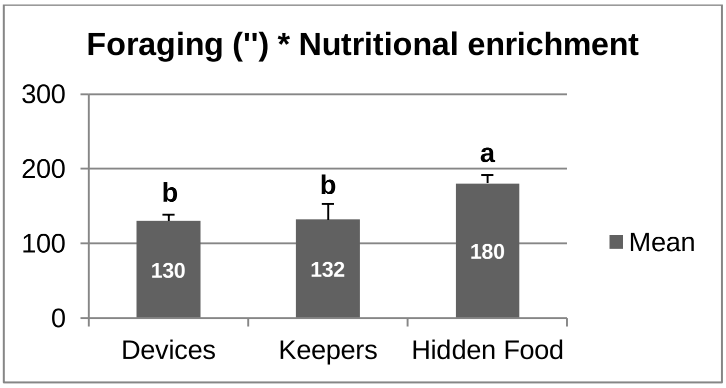


Graphic 3 - Analysis relating the presence (P) and the absence of the male (A and OOS) with the time the females spent foraging in 5' intervals. [a] Statistical significant when compared to A or OOS ([b]) (p<0,05). N=372

It was observed that the difference when comparing the presence with the absence of the male was statistically significant. The females spend less time eating/searching for food when the male is present than when he is absent or out of sight (OOS), i.e., when he is not in the same physical space as the females that were being observed for that period. This is easily explained because if the male is not with them, they do not have visual contact with him and therefore they won't change their behaviour. This can be explained by the fact that they are still getting used to his presence and / or that all females show sexual interest in him, and as a result, less interest in their surroundings. As determined by Rasmussen & Schulte (1998) most females remain still when male approaches them. So, if they are paying attention to him, they won't do anything else, such as foraging.

Too see the role of environmental enrichment more specifically if the nutritional part of the programme has any influence on their foraging behaviour, the two variables were statistically analysed for Zoo 1 and Zoo 2 individually. The Zoo 3 was excluded from this analysis because it doesn't have enrichment programs.

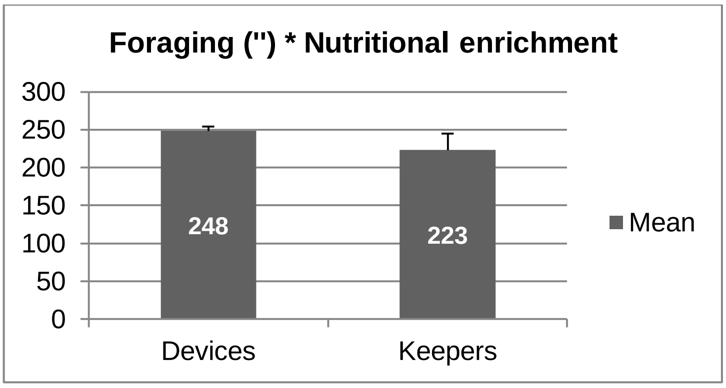
At Zoo 1, the results show a significant difference in their foraging behaviour when there is hidden food comparing to when they are fed by keepers or when there is only enrichment devices available (Graphic 4).



Graphic 4 - Results of the comparison between the number of seconds in 5' intervals that elephants spent foraging with the nutritional enrichment at Zoo 1. [a] Statistical significant when compared with the other two variables ([b]) ($p<0,05$). N=372

If related with nutritional enrichment, the elephants at Zoo 1 showed an increased foraging behaviour when there is hidden food in the indoor space, because they spent a lot of time searching for it, so it is a very good way to keep them occupied and make them work for their food, increasing their mental and physical activity levels (Taylor & Poole, 1998).

In the Zoo 2 their enrichment program didn't have the hidden food component and therefore, only the nutritional enrichment by keepers and by nutritional devices was analysed (Graphic 5).

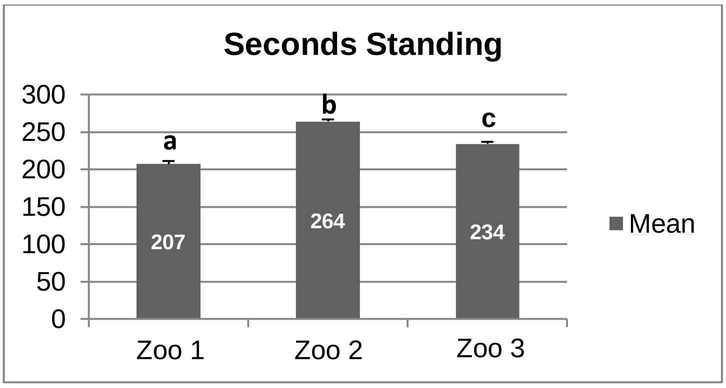


Graphic 5 - Results of the comparison between the number of seconds in 5' intervals that elephant spent foraging with the nutritional enrichment at Zoo 2. N=252

In Zoo 2 there wasn't any statistical significance between the results when relating the foraging behaviour with the nutritional environment, but as explained before, she is housed alone and consequently she spends great amount of her time eating, so this result is predictable. Nevertheless, the food is not easily available to her and she always has to work a little to get her hay, for example.

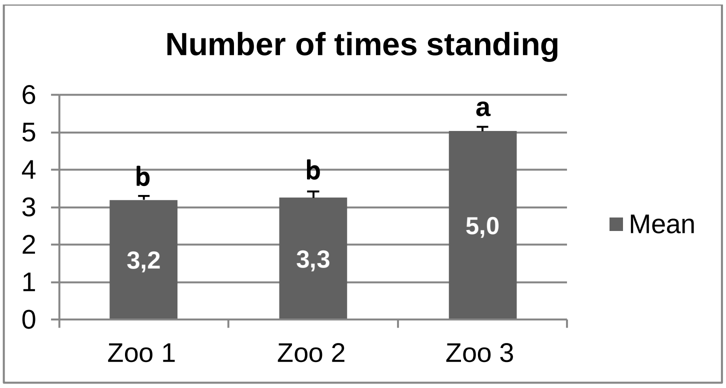
1.2. Locomotion/Standing Behaviour

The second basic behaviour analysed for each Zoo was the standing behaviour (Graphic 6). The Zoo 2 is the Zoo where the elephant spent more time standing with no movements and the Zoo 1 was the one where they spent less time standing still. There is statically significant difference between the three Zoos.



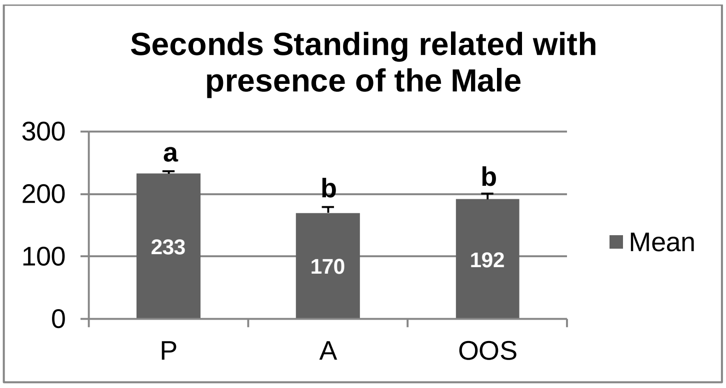
Graphic 6 - Number of seconds standing in 5' intervals in each Zoo. [a, b, c] Statistical significant ($p<0,05$). $N_{Zoo\ 1}$= 372; $N_{Zoo\ 2=}$ 252; $N_{Zoo\ 3=}$ 527

The other component of the standing behaviour is the number of times they stand, and hence, number of times they walk. This behaviour was also analysed for each Zoo (Graphic 7).



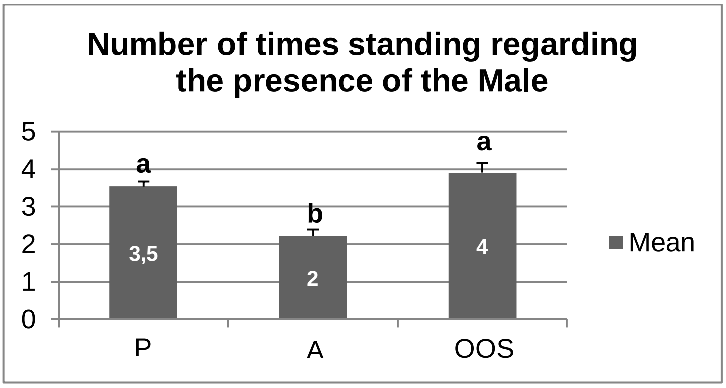
Graphic 7 - Number of times standing in 5' interval for each Zoo. [a] Statistical significant when compared to Zoo 1 and 2 ([b]) ($p<0,05$). $N_{Zoo\ 1}$= 372; $N_{Zoo\ 2=}$ 252; $N_{Zoo\ 3=}$ 527

The Zoo with the higher number of stopped times was the Zoo 3, followed by Zoo 2 and then by Zoo 1. There is only statistical significance between Zoo 3 and the other Zoos, and this is expected because it has a large plot that allows the elephants to spend a lot of time foraging, so they walk and stop many times during the five-minute intervals. Also, they spend part of their time bathing and mud bathing, as well as play with each other, increasing the number of times they move. In Zoo 2 the female spent most of her time eating in the same position. Regarding the results obtained in Zoo 1, we evaluated the influence of the presence / absence of the male in this behaviour (Graphic 8 and 9).



Graphic 8 - Number of seconds that females spent standing in the presence (P) / absence of the male (A and OOS) in 5' intervals at Zoo 1. [a] Statistical significant when compared to A and OOS ([b]) (p<0,05). N=372

In his presence, females stand longer than in his absence or when he is out of sight. So it can be demonstrated, for Zoo 1, that the presence of the male influences the time that females stand, as described before by Rasmussen & Schulte (1998).

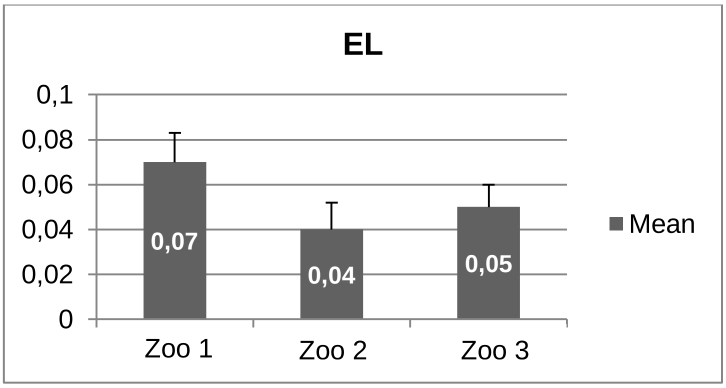


Graphic 9 - Number of times standing in the presence (P) / absence of the male (A and OOS) in 5' intervals at Zoo 1. [a] Statistical significant when compared with male absence ([b]) (p<0,05). N=372

On average, they walk/stand more times in his presence and when he is out of sight than in his absence. There is statically significance for the presence and absence of the male, but not when he is in the indoor space. This may be related with the fact that they tend to stop more when the male approaches them, and when he moves away they go back to him, increasing the number of times they walked/stopped.

1.3. Elimination behaviour

Regarding the elimination behaviour, its frequency was analysed for each Zoo (Graphic 10).



Graphic 10 - Frequency of elimination in 5' intervals at each Zoo. $N_{Zoo\ 1}$= 372; $N_{Zoo\ 2}$= 252; $N_{Zoo\ 3}$= 527

The Zoo with the higher frequency in elimination (defecation and urination) is Zoo 1.

To try to understand this result, the behaviour was related to the presence / absence of the male (Table 6).

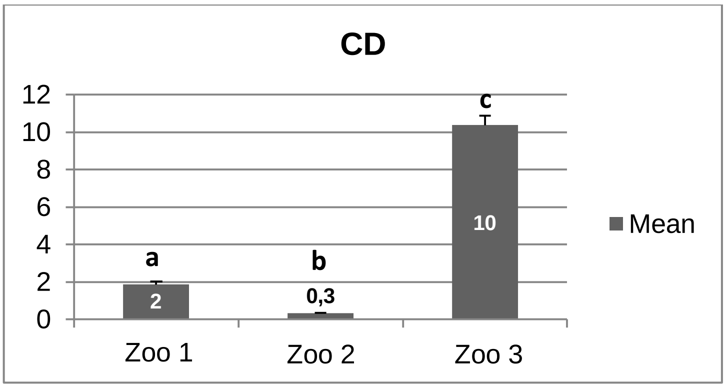
Table 6 - Elimination behaviour (EL) related with the presence (P) / absence (A and OOS) of the male (M) at Zoo 1. EL: 1- manifested behaviour. N=372

			M			Total
			P	A	OOS	
EL	0	% within EL	52,7%[a]	31,1% [a]	16,1% [a]	100,0%
		% within M	90,6% [a]	**96,4%** [a]	96,6% [a]	93,3%
	1	% within EL	76,0% [a]	16,0% [a]	8'0% [a]	100,0%
		% within M	**9,4%** [a]	3,6% [a]	3,4% [a]	6,7%
Total		% within EL	54,3%	30,1%	15,6%	100,0%
		% within M	100,0%	100,0%	100,0%	100,0%

It was observed an increasing frequency of elimination when the male was present, but the results were not statistical different, as suggested by literature (Rasmussen & Schulte, 1998; Poole, 1999; Bagley, *et al.*, 2006). More observations with the male present should be performed in order to clarify this result. However, observations showed that the behaviour was often after the male approach, as described in the literature.

1.4. "Cooling Down"

The Cooling Down is the behaviour related with the ears' flapping of the elephants, most of the time associated with thermoregulation. The frequency of this behaviour was analysed for each Zoo (Graphic 11).



Graphic 11 - Frequency of cooling down behaviour in 5' intervals at each Zoo. [a, b, c] **Statistical significant ($p<0,05$). $N_{Zoo\ 1}$= 372; $N_{Zoo\ 2}$= 252; $N_{Zoo\ 3}$= 527**

The results have statistical significance between all the Zoos. Zoo 3 was the Zoo where the cooling down behaviour was more times manifested, followed by the Zoo 1 and finally the Zoo 2. From Zoo 1 to Zoo 3 the temperatures have been rising, since the data collection took place in November, March and June, with average temperatures around the 7.25°C, 9°C and 22.7°C, respectively.

The ears' flapping are associated with the regulation of body temperature, whereby an increase of this behaviour should be linked to the environmental temperature (Table 7).

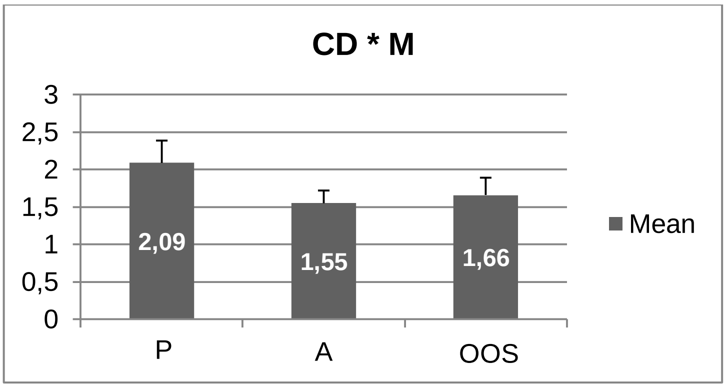
Table 7 - Correlation between the frequency of Cooling Down with the environmental temperature. N=1151

	CD	°C
CD	1	0,457
°C	0,457	1

We observed that this behaviour and the temperature are directly related as described by Buss & Estes in 1971. Also, they demonstrated that ear flapping increased significantly when the air temperature exceeded about 25°C. We obtained similar results with the significant increase in this behaviour at Zoo 3 where temperatures were ± 23°C (Graphic 11).

It would, however, be expected that the Zoo 2 had a slight increase in this behaviour when compared to Zoo 1. On the other hand, F5 is housed alone and as Mackay in 1973 stated, the ears' flapping may be also considered as social signal. So, it is expected that F5 performs less times this behaviour.

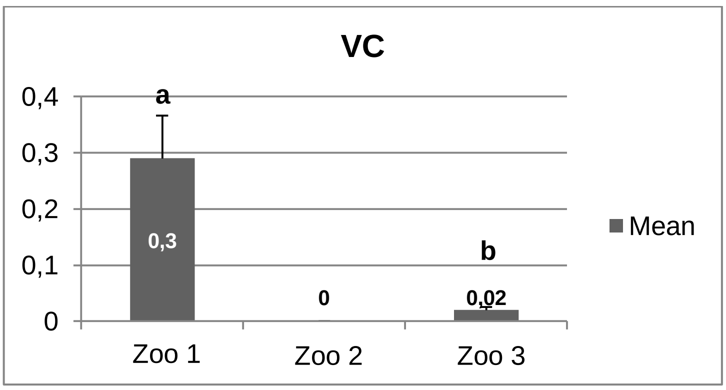
We tried to prove that the increased ears' movements at Zoo 1 were also associated with the presence of the male (Graphic 12) as he is a new variable that can change their emotional behaviour, for example, excitement and fear. But, although we can observe an increase of this behaviour manifestation when the male is present (P), it can't be proved statistically. A larger number of observations with situations in which the male is with the females should be done.



Graphic 12 - Cooling Down behaviour related with the presence (P) / absence of the male (A and OOS) in 5' intervals at Zoo 1. N=372

1.5. Vocalisations

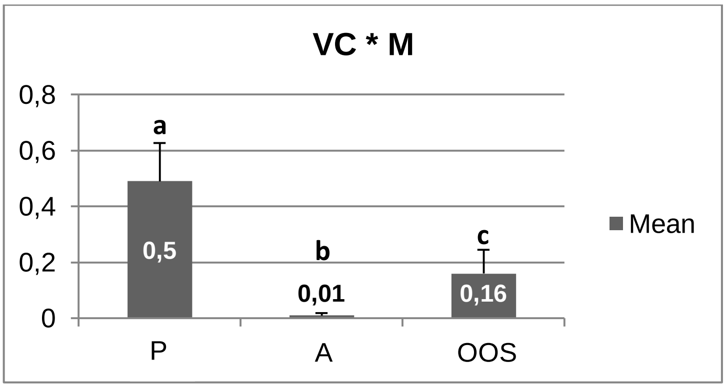
The frequency of vocalisations were analysed for each Zoo (Graphic 13).



Graphic 13 - Frequency of vocalisations in 5' intervals at each Zoo. [a] Statistical significant when compared with Zoo 3 ([b]) ($p<0,05$). $N_{Zoo\ 1}= 372$; $N_{Zoo\ 2}= 252$; $N_{Zoo\ 3}= 527$

The Zoo where we observed more vocalisations was at Zoo 1. Between this Zoo and the others there is statistical significance, but not between Zoo 2 and 3. Zoo 2 didn't produce any vocalisations. These results appear to demonstrate that this behaviour happens more times when there is more than one animal held together, mainly females, since most elephant vocalisations are part of interactive bouts or choruses that contain overlapping vocalisations (Langbauer, 2000; Soltis, *et al.*, 2005).

The number of vocalisations produced by females at Zoo 1 was higher than the vocalisations produced at Zoo 3 which has more animals. In the observations, it appeared that most of them were performed in the presence of the male at the Zoo 1 (Graphic 14) and when there was aggressive behaviour, in this case to the Zoo 1 and 3 (Table 8). Therefore, statistical analyses were performed to both hypotheses.



Graphic 14 - Frequency of vocalisations related with presence (P) / absence of the male (A and OOS) in 5' intervals at Zoo 1. [a, b, c] Statistical significant (p<0,05). N=372

There is statistical significant difference proving that the presence of the male compared to his absence in Zoo 1, leads to more vocalisations.

Table 8 - Correlation between the frequency of vocalizations and the aggressive behaviours at Zoo 1 and 3. N=899

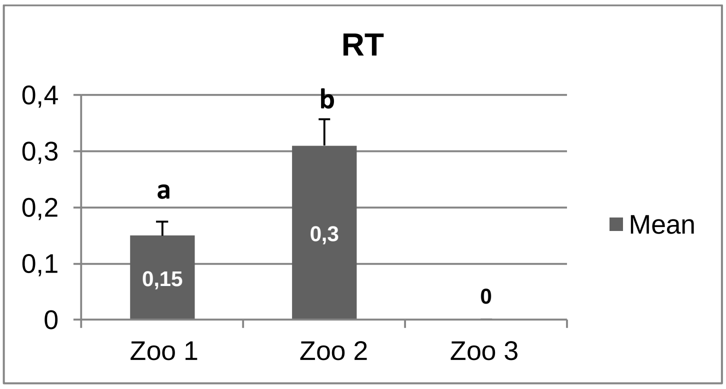
	VC	AG
VC	1	0,152
AG	0,152	1

The Zoo 2 was excluded from this comparison because aggressive behaviour is part of the social behaviours and the elephant is alone and therefore does not show this type of behaviour. The aggression behaviour and the production of vocalisations are directly related (Table 8) (Soltis, et al., 2005).

1.6. Resting Trunk

The “Resting trunk” is the last behaviour of the basic ones that was analysed. Is a behaviour shown by elephants when they are resting, possibly asleep (McKay, 1973) and rarely takes place during the day, as they spent those hours to eat.

It was statistically analysed for each Zoo (Graphic 15).



Graphic 15 - Mean of the number of resting behaviour performed at all the Zoos in 5’ intervals. [a, b] Statistical significant ($p<0,05$). $N_{Zoo\ 1}= 372$; $N_{Zoo\ 2}= 252$; $N_{Zoo\ 3}= 527$

Values in all the Zoos have statistically significant difference between them. The female housed in Zoo 2 was the elephant which rested her trunk more times, comparing to the other Zoos. The absence of other animals may also lead to smaller stimuli, causing her to stay still for a long period and eventually resting.

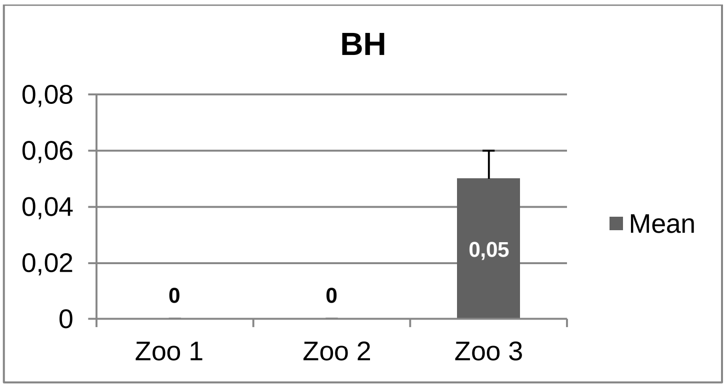
In Zoo 3 this behaviour was not manifested during observations and can be explained by the fact that they have very similar conditions to their natural habitat, spending a lot of time foraging.

2. Body care Behaviour

The body care behaviours were considered to be baths, dust baths, mud baths and rub.

2.1. Baths

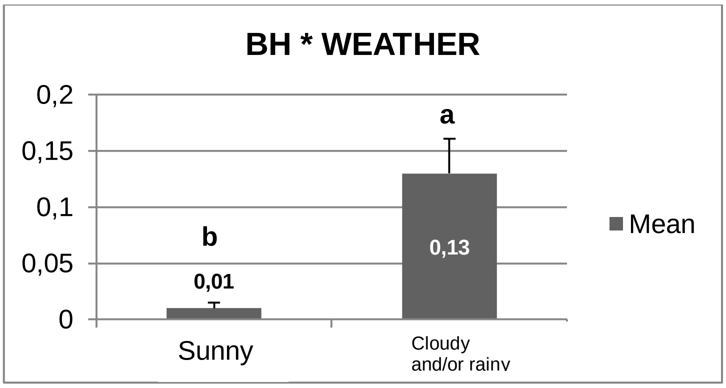
Baths were only was performed at Zoo 3 (Graphic 16).



Graphic 16 - Mean of the number of baths performed in 5' intervals at each Zoo. $N_{Zoo\ 1}$= 372; $N_{Zoo\ 2}$= 252; $N_{Zoo\ 3}$= 527

One reason for bathing not having been performed at Zoo 1 can be due the fact that at that time it was quite cold, although the Zoo personal said that they still bath in winter times and was probably bad luck not to have observed this behaviour.

At Zoo 3, the elephant's keepers said that they liked to bathe when the weather was not very good, for example, if it was cloudy or rainy. So, statistical analysis was performed relating the occurrence of baths with the weather conditions (Graphic 17). Thus, two groups of conditions were created (Sun and / or clear sky and rainy and / or cloudy days).

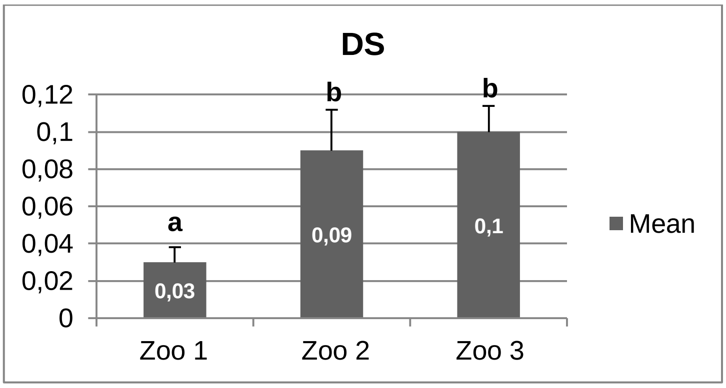


Graphic 17 - Comparison between the occurrences of baths and the weather conditions in 5' intervals. [a] Statistical significant when compared with weather 1 (p<0,05). N=527

There is statistically significant difference, proving that the behaviour is carried over when the weather is cloudy and / or rainy. However, we couldn't find any literature to support this finding. More observations with different animals in different Zoos should be performed.

2.2. Dust Baths

The mean frequency of Dust Baths were analysed for each Zoo (Graphic 18).



Graphic 18 - Frequency of Dust Baths in 5' intervals at each Zoo. [a] Statistical significant when compared with Zoo 2 and 3 ($p<0,05$). $N_{Zoo\ 1}$= 372; $N_{Zoo\ 2}$= 252; $N_{Zoo\ 3}$= 527

There is a growing manifestation of this behaviour from Zoo to Zoo, and Zoo 1 is the one manifesting it less and Zoo 3 the one the one manifesting it more. The results are statistically significant between Zoo 1 and the other Zoos.

Dusting is also a social activity, and it may be important in the cohesion of elephant groups. This may be another reason to prove the significant increased manifestation of this behaviour at Zoo 3, the Zoo with more animals, and therefore, more social interactions. Also, it is described that Asian Elephants (Zoo 1) spend dust bathing once temperature is above 13°C and below that temperature it is rarely observed, so is understandable that dusting in Zoo 1 was significantly less performed than in the others Zoos (Rees, 2002), where temperatures were ±7°C at that time.

To see if there was any influence of the environmental temperature with this behaviour, a correlation between the two variables were performed (Table 9).

Table 9 - Correlation between the occurance of Dust Baths and the environmental temperature (ºC). N=1151

	DS	°C
DS	1	0,114
°C	0,114	1

There is statistical significance between the dust bath and environmental temperature with a positive correlation, i.e., when there is an increase in temperature, there is an increase in the manifestation of this behaviour (Rees, 2002).

Regarding the behaviour of body care, rub, dust baths and mud baths are often related as described in the literature review. Thus, it was carried out a statistical correlation between the three variables to see if in fact they are related to each other (Table 10). The results were highly significant.

Table 10 - Correlation between dust baths, mud baths and rub behaviours. * Statistical significant when compared the three variables (p<0,05). N=1151

	RB	DS	MD
RB	1	,124*	,239*
DS	,124*	1	,083*
MD	,239*	,083*	1

Rub was often manifested when the dusting and the mudding were too, mainly when mudding occurred (Lehnhardt, 2006).

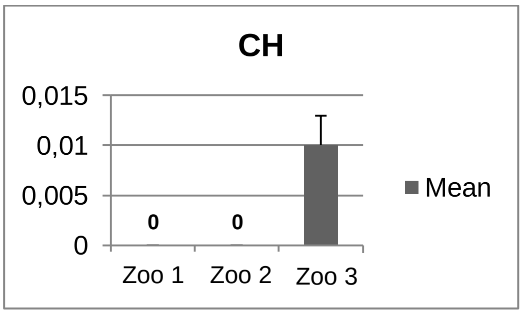
3. Social Behaviours

The social behaviours that were observed were chase, affiliation, object play, aggression, sparring, beating trunk and sexual behaviours (caressing and mating).

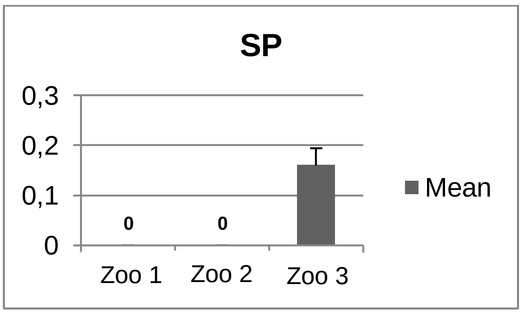
The female elephant at Zoo 2 does not manifest any social behaviour because she is held alone. The only social behaviour is the "object play" and it is more related with the enrichment devices than the social component of the animals' behaviour.

3.1. Chase and Sparring

Chase and Sparring were two behaviours only observed at Zoo 3 (Graphics 19 and 20). Zoo 3 was the Zoo with most social interactions due to the fact that it has a larger number of individuals and they are closely related with each other, being possible to distinguish three different "herds".



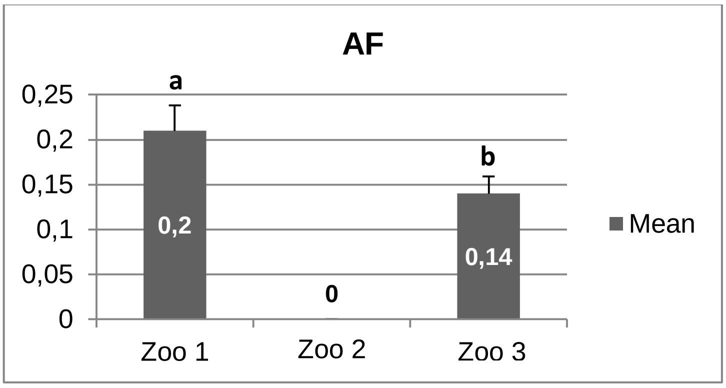
Graphic 19 - Chasing at each Zoo.



Graphic 20 - Sparring at each Zoo.

3.2. Affiliation

Affiliation is another social interaction that is related with tactile communication. This behaviour was observed in Zoo 1 and Zoo 3 (Graphic 21). There is statistical significance between the Zoos.

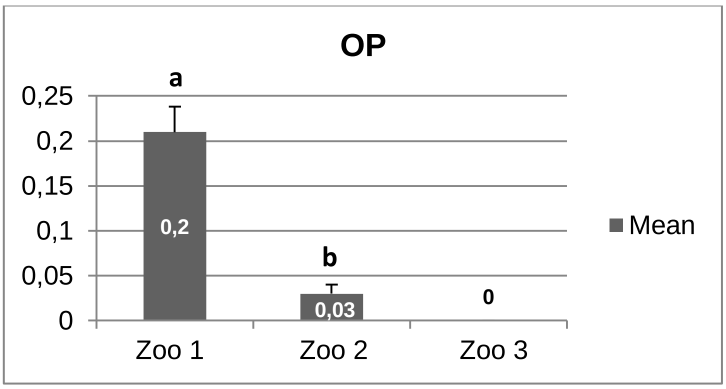


Graphic 21 - Frequency of Affiliation Behaviour in 5' intervals at each Zoo. [a, b] Statistical significant (p<0,05). $N_{Zoo\ 1}$= 372; $N_{Zoo\ 2=}$ 252; $N_{Zoo\ 3=}$ 527

The Zoo 1 was the Zoo demonstrating more affiliative behaviours. During the observations, it was a behaviour that occurred more between animals that were related to each other and between "aunties" and the calfs (Langbauer, 2000). In captivity the allomothers may be not related with the calf's mother. Zoo 3 probably demonstrated less times this behaviour due to the time they spent foraging.

3.3. "Object Play"

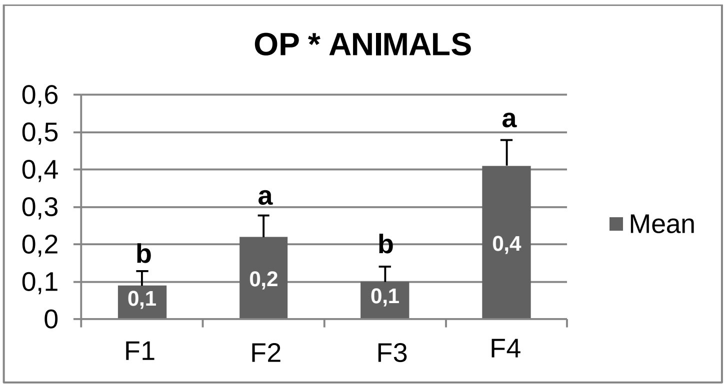
"Object Play" demonstrates the relation between the animals and the enrichment devices at each Zoo (Graphic 22). There is statistical significance between the Zoos.



Graphic 22 - Average number of times the elephants at each Zoo played with the enrichment devices in 5' intervals. [a, b] Statistical significant (p<0,05). $N_{Zoo\ 1}$= 372; $N_{Zoo\ 2=}$ 252; $N_{Zoo\ 3=}$ 527

Zoo 1 is the Zoo with more enrichment devices and was the Zoo that expressed more often this behaviour. This can mean that their elephants have a positive interaction and response to the enrichment program. Zoo 3 doesn't have any enrichment devices, thus, this behaviour was not manifested.

To see which animal interacted more with the devices, a statistical analysis was performed between the object play and the different animals at Zoo 1, since there is only one female at Zoo 2.

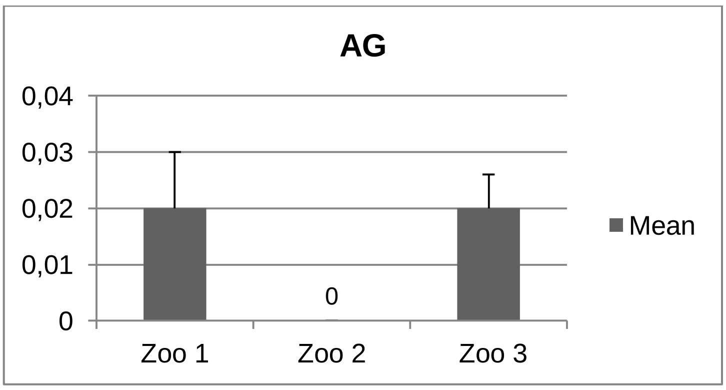


Graphic 23 - Average number of times the elephants at Zoo 1 played with the enrichment devices in 5' intervals. [a] Statistical significant (p<0,05) when compared to [b]. N=372

The animal who played more with the enrichment devices was F4, almost twice as often when compared to F2, which comes in second place. The difference is only statistically significant between F4 and F1 and F3, but not with F2.

3.4. Aggression Behaviour

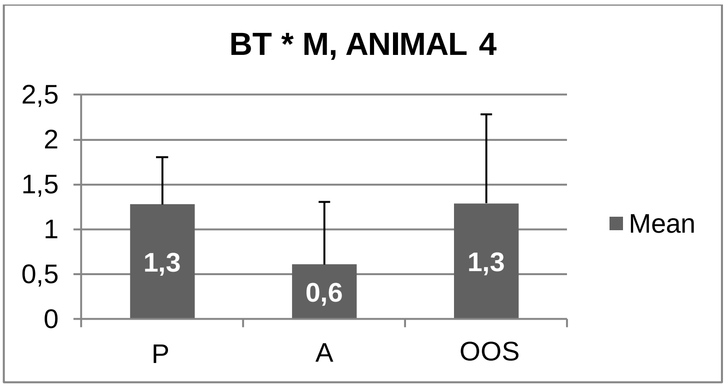
Aggression behaviour was another social interaction observed in Zoo 1 and 3 (Graphic 24). In both Zoos the aggressions were made mainly by the dominant males.



Graphic 24 - Frequency of Aggressions performed at each Zoo in 5' intervals. $N_{Zoo\ 1}$= 372; $N_{Zoo\ 2}$= 252; $N_{Zoo\ 3}$= 527

3.5. Beating Trunk

"Beating trunk" was a behaviour only manifested by F4 at Zoo 1. It is described that annoyed elephants may repetitively thumb their trunks on the ground or objects (Rasmussen L. , 2006). During the observations, it seemed that she performed this behaviour everytime the male was around. In order to confirm it, statistical analysis was made (Graphic 25).



Graphic 25 - Relation between the performance of Beating Trunk behaviour by F4 with the presence (P) / absence of the male (A and OOS). N=372

Even though it is possible to observe an increasing trend of beating trunk when the male is present and / or present but indoor, there is no statistically significant difference between these and its absence, only a tendency.

3.6. Caressing and Mating

Caressing and mating are sexual behaviours, where caressing can be understood as "courtship". The two components of the sexual behaviours were only performed at Zoo1.

To see if the two components were related, i.e., if caressing happened, mating also happened, a pearson correlation was made between the two variables (Table 11).

Table 11 - Correlation between Caressing and Mating in 5' intervals. * Statistical significant when the variables were compared ($p<0,05$). N=372

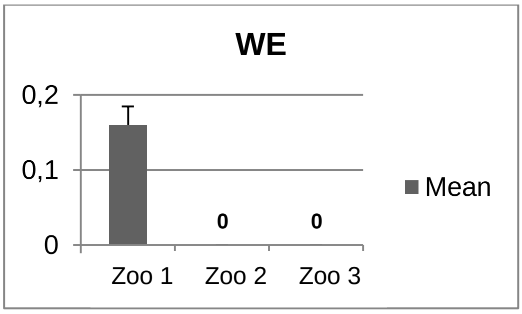
	MT	CR
MT	1	,793*
CR	,793*	1

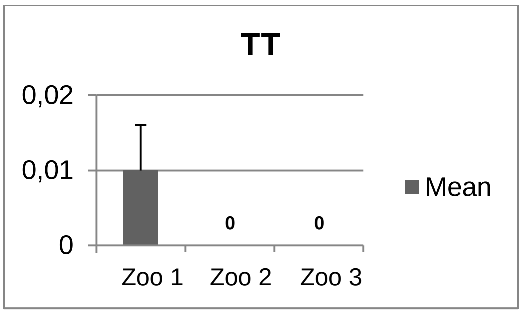
There is a very significant correlation between them, proving that mating almost always occurs when caressing occurs.

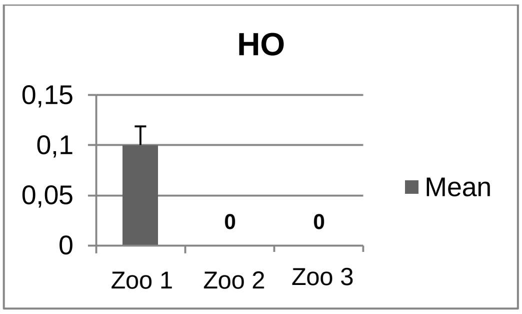
During the observations one of the female elephants appeared to be very receptive and interested in the male. The other elephants also seemed interested but the male always ended up preferring F3, showing that she was receptive (Schulte, 2006; Hildebrandt, et al., 2011).

4. Stereotypic Behaviour

It was recorded three types of stereotypic behaviour: the weaving (WE), the trunk tossing (TT) and the head bobbing (HO). For each different type was analysed the average times they were performed at each Zoo (Graphic 26).







Graphic 26 - All different types of Stereotypic behaviours, performed at each Zoo in 5' intervals. $N_{Zoo\ 1}$= 372; $N_{Zoo\ 2=}$ 252; $N_{Zoo\ 3=}$ 527

In the observations made by video captures, the Zoo 1 was the only with stereotype behaviours, being weaving the most manifested form. The Zoo 1 was the only Zoo with Asian elephants and it is described that the Asian species perform more stereotypic behaviour when compared to the African species in captivity (Mason & Veasey, 2010 B).

Nevertheless, F1 and F2 were the animals performing more stereotypic behaviours but they are only in that collection very recently, and therefore, their behaviour may not result from this Zoo but from previous institutions, as the aetiology of stereotypic behaviour in Zoo elephants is extremely difficult to study because of their longevity and the fact that most have been moved from Zoo to Zoo, from circus, from logging camps or even from the wild, taking their stereotypies with them, not reflecting the welfare conditions at the moment (Rees, 2004;

Mason & Veasey, 2010 B). Zoo 1 has an excellent enrichment program, and the proof is that the other two females, whom have been in the collection for 11 years don't show almost any stereotypic behaviour.

Statistical analyses were made to compare the manifestations of stereotyped behaviours with several variables in order to figure out which was the "trigger" for this behaviour.

The first analysis was performed to evaluate the presence stereotypic behaviours when the females were in the indoor or outdoor space (Table 12).

Table 12 - Crosstabulation between the performance of Stereotypic Behaviour (SB) and the presence of the females in the indoor or the outdoor space in 5' intervals. INDOOR/OUTDOOR: 1- Indoor; 2- Outdoor; 3- In both spaces. SB: 0- No behaviour manifestations; 1- Manifestation of stereotypic behaviour. . [a and b] Statistical significant between 1 and 2 (p<0,05). N=372

			INDOOR/ OUTDOOR			Total
			1	2	3	
SB	0	% within SB	35,1% [a]	64,6% [b]	0,3% [a,b]	100,0%
		% within INDOOR/ OUTDOOR	**97,4% [a]**	81,6% [a]	100,0% [a,b]	86,6%
	1	% within SB	6,0% [a]	94,0% [b]	0,0% [a,b]	100,0%
		% within INDOOR/ OUTDOOR	2,6% [a]	**18,4% [b]**	0,0% [a,b]	13,4%
Total		% within SB	31,2%	68,5%	0,3%	100,0%
		% within INDOOR/ OUTDOOR	100,0%	100,0%	100,0%	100,0%

This behaviour was manifested more often when the animals were in the outdoor space. This results presented have statistical significant difference.

The second factor analysed was the “”DOORS”, i.e., if they are locked in the indoor or outdoor space or if they have access to both facilities (Table 13).

Table 13 - Crosstabulation between the stereotypic behaviour (SB) and the DOORS (1- Closed in; 2- Closed out; 3- open doors) in 5' intervals. . [a, b, c] Statistical significant between the three variables (p<0,05). N=372

			DOORS			Total
			1	2	3	
SB	0	% within SB	32,3% [a]	10,9% [b]	56,8% [c]	100,0%
		% within DOORS	**98,1% [a]**	54,7% [b]	**90,6% [c]**	86,6%
	1	% within SB	4,0% [a]	58,0% [b]	38,0% [c]	100,0%
		% within DOORS	1,9% [a]	**45,3% [b]**	9,4% [c]	13,4%
Total		% within SB	28,5%	17,2%	54,3%	100,0%
		% within DOORS	100,0%	100,0%	100,0%	100,0%

Regarding the Indoor / Outdoor access, they exhibit more stereotyped behaviours when they are closed in the outdoor space (i.e., during the period when the keepers are cleaning the interior space and preparing the nutritional enrichment by hiding food in the sand). They probably "recognize" this time of the day as "pre-feeding" because when the doors are opened they go to the indoor space and they have the hidden food as nutritional enrichment, and therefore an increase in foraging, resulting in a significant decrease in this behaviour (Taylor & Poole, 1998).

It's when they are closed in the indoor space that they manifest less times these behaviours. This may be because when they are inside they are busy looking for the hidden food. Therefore, this variable was also statistical analysed (Table 14).

Table 14 - Crosstabulation between the performance of SB and the absence of Nutritional enrichment (0) or the hidden food in the indoor space (2). . [a, b] Statistical significant when compared the two variables (p<0,05). N=372

			Nutritional enrichment		Total
			0	2	
SB	0	%	80,80% [a]	**96,90% [b]**	86,50%
	1	%	19,20% [a]	**3,10% [b]**	13,50%
Total		%	100,00%	100,00%	100,00%

When there is hidden food in the enclosure, they perform less stereotypic behaviours when compared to a scenario with no nutritional enrichment.

The other factor analysed was the presence/absence of the male (Table 15).

Table 15 – Crosstabulation between the SB with the presence/absence of the male in 5' intervals. [a, b] Statistical significant between the presence and the absence of the male (p<0,05). N=372

			M			Total
			P	A	OOS	
SB	0	% within SB	59,0% [a]	25,5% [b]	15,5% [a,b]	100,0%
		% within M	**94,1% [a]**	73,2% [b]	86,2% [a,b]	86,6%
	1	% within SB	24,0% [a]	60,0% [b]	16,0% [a,b]	100,0%
		% within M	5,9% [a]	**26,8% [b]**	13,8% [a,b]	13,4%
Total		% within SB	54,3%	30,1%	15,6%	100,0%
		% within M	100,0%	100,0%	100,0%	100,0%

When compared with the presence / absence of male, stereotypic behaviours are manifested significantly less in his presence and more in his absence. So, he was considered to be a positive factor.

F5, who is housed alone at Zoo 2 and therefore has no social interactions, should have manifested some sign of poor welfare, such as stereotypic behaviour. However, she does not demonstrate any sign of discomfort, and she is pretty used to her routine. When her companion died, the Zoo staff had a meeting about her welfare. They decided that due to her age, to her time in collection and to her bad eyesight, she would be better alone there than transferred to a new place. All of her behaviours are normal and she spends a lot of time foraging, which is the expected.

Zoo 3 is the Zoo with the perfect environmental conditions, giving the elephants the opportunity to perform all their natural behaviours.

V. Conclusions

1. Foraging seems to be influenced by foraging conditions of Zoos, presence of the male and nutritional enrichment.
2. Locomotion and the time they stand are influenced by the presence of the male. They stand longer, but they make more movements, suggestive of anxious behaviour (no negative connotation).
3. Ears' flapping (cooling down behaviour) increase with environmental temperature.
4. Vocalizations seems to be affected by number of animals (n>1), presence of the male and aggression behaviour.
5. Baths are influenced by weather conditions.
6. Dusting is correlated with the environmental temperature.
7. Rub is associated with dusting and mudding, as it often occurs when these behaviours recur.
8. Chasing and sparring are probably influenced by the number of animals as it was only performed at Zoo 3, where more social ties exist.
9. Enrichment devices cause an increase in play behaviour.
10. Caressing and Mating are highly related, mainly if a female is receptive.
11. Stereotype behaviour is less manifested in the presence of the male and when nutritional enrichment favors foraging behaviour. These results regard only to Zoo 1, and may not be the same for another Zoo.

The assessment of elephant behaviour in captivity will help to adopt measures to improve management procedures. These will have a positive impact on the animals' life leading to optimised conservation.

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Webgraphy

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Annex I

Survey

Elephant care:

- Keepers contact:
- Feet care: How often – wash/pedicure?
- Hose: How often

Management:

- Daily
  - Food quality and quantity:
    - *Ad libitum* / Hours?
  - Enclosure hours? (Sleep always indoor?):
  - Outdoor? At what time in the morning?:
  - Any management at night?:
- Seasonal
  - Any differences between seasons? Time of enclosure, for example.

Elephant background

- Any medical treatment at the time?
- Medical Conditions

Enrichment Programs

- Nutritional
- Sensory
- Enrichment devices
- Social
  - Same specie
  - Different species
- Environmental
- Training