FUNCTION OF PLAY IN BEHAVIORAL ENRICHMENT

OF CAPTIVE ASIAN ELEPHANTS

(ELEPHAS MAXIMUS)

By

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"Knowledge and understanding are life's faithful companions who will
never prove untrue to you. For knowledge is crown, and
understanding your staff; and when they are with
you, you can posses no greater treasure."
Kahlil Gibron

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"*Thus spoke the speechless animal whom my heart had understood*."

Kahlil
Gibran

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DISSERTATION RATIONALE

Even in the best situations, the artificial social constructs of captivity alter natural elephant behavior. Unfortunately, reproduction is an area in which stress plays a particularly negative role. Asian elephants are a powerful and intelligent species that require environmental enrichment in captive situations to prevent boredom and subsequent aberrant or stereotypical behavior. We propose that by introducing play as a form of behavioral enrichment, the elephants' stress levels will decrease, and their sense of well-being will increase and thereby enhance their quality of life and reproductive success. It is to this purpose that this study is dedicated.

CHAPTER I

A COMPREHENSIVE PREFACE TO LIVING MEMBERS OF ORDER PROBOSCIDAE AND PRESENT DAY POPULATION DYNAMICS AS WELL AS SOCIAL AND REPRODUCTIVE BEHAVIOR OF ASIAN ELEPHANTS (ELEPHAS MAXIMUS)

Chapter Rationale

Chapter I is a study of the origin of the contemporary Asian elephant *(Elephas maximus)* as well as its present day natural history. To accurately examine a species it is necessary to understand its early development and modern lifestyle.

Fossil Record and Evolution of the Elephant

Today's technology has the potential of scrutinizing DNA, the "building blocks of life, to validate or refute the established classification of animals" (Bischof & Duffield, 1994; Yang, *et al.,* 1996). Historically, classification has been primarily based on anatomy. Because of their durability, bone and tooth structure can hold important clues to relatedness, as evidenced in Shoshani, (1992) (see supplemental file, Figure 1). Such relics are the principal contributors to the "fossil record," a chronology of fossil appearances usually in rock layers, marking the passing of geological time. Shoshani (1992) illustrated the importance of tooth structure in establishing an accurate account of elephant evolution. He emphasized that as elephants evolved, their body size increased, which resulted in increases of tooth size, along with increase of complexity of the chewing surfaces. Another example of the importance of anatomical features in establishing relatedness is derivation of tusks in elephants. In most animals with tusks, canines are the antecedent of tusks; however, elephants' tusks evolved from incisors (Maglio, 1973). This distinction has provided evidence used to trace elephants' line of descent as well as serving as a criterion for their membership in order Proboscidae.

Proboscidea comes from the Greek *proboscis*, meaning nose, and the word *elephant* means "ivory." The members of this order have existed for 50-55 million years, undergoing three major adaptive radiations (Shoshani, 1992; Madsen, et al., 2001; Kappelman *et al*., 2003). The first radiation took place from the mid-Eocene throughout the Oligocene epochs (25-55 million years ago) accounting for the earliest proboscideans moeritheres, numidotheres, barytheres, deinotheres, palaeomastodons, and mammutids (Madsen, et al., 2001; Kappelman et al., 2003). A second radiation occurred during most of the Miocene era (approximately 10-24 million years ago) and included the gomphotheres and stegodontids (Shoemaker & Knight, 1999). The third adaptive radiation came about during the last part of the Miocene and during the Pliocene and Pleistocene epochs (8,000 to 10 million years ago). Family Elephantidea evolved all through this period, filling open niches as they progressed along their developmental chronicle (Shoemaker & Knight, 1999; Madsen, *et al*., 2001; Kappelman et al., 2003).

The earliest member of Proboscidea was genus *Moeritherium* (35-50 million years ago; Eocene/Oligocene ages) (Romer, 1966) (see supplemental file, Figure 2). They were pig-sized animals that lived a semi-aquatic life style similar to that of a hippopotamus. They displayed the antecedent of an enlarged incisor but no evidence of a trunk (see supplemental file, Figure 2). *Moerithrium* is believed to be in the suborder

Tethytheria (Lavergne *et al.*, 1995) that included three different orders: 1. order Sirenia, which emerged as totally aquatic; 2. order Hyracoidea, a medium-sized rodent-like animal and lastly 3. order Proboscidae, incorporating modern elephants. *Moerithrium* is also believed to be the predecessor to the families Numidotheriidae (see supplemental file, Figure 2), Barytheriidae, and Deinotheriidae (see supplemental file, Figure 2).

Unlike *Moeritherium*, the Palaeomastodons (see supplemental file, figure 2) (30-36 million years ago; Oligocene age) were early members of Proboscidae that resembled a present-day elephant. The nose of the Palaeomastodons resembles a small trunk; their incisors were greatly enlarged and they had the beginning of lower jaw tusks. Palaeomastodons served as the antecedent to families Mammutiidae and Gomphotheriidae (see supplemental file, Figure 2).

Gomphotheriidae (5-22 million years ago; late Oligocene/Miocene ages) contains a variety of animals thought to have evolved from Palaeomastodons. This family became the "catch all" for many of the taxa that demonstrated a general resemblance to the body plan of Gomphotheriidae, and whose taxonomic position was not clear. Some representatives of this group exhibited tusks only in their upper jaw while others had tusks in both upper and lower jaws. The supposition is that this family had a well-developed trunk with long legs and a short neck much like Mammutidae.

Mammutidae (20 million- 10,000 years ago; mid Oligocene/late Pleistocene ages) descended from the earlier gomphotheres. "Mammut" comes from the Tartar word Mamut meaning "a gigantic burrowing rat." Mammutidae was the family of the mastodon, an elephant-like animal (see supplemental file, Figure 3). *Mastodon* is taken from the Greek meaning "nipple tooth" designating a distinctive feature of their teeth

(Shoshani, 1992; Shoshani, *et al.*, 1996; Shoemaker& Knight, 1999). They were about the same size as today's elephant but were stockier, with a heavier frame. Their foreheads were flattened, rising to prominent domed crowns; they had large curved tusks in the upper jaw and a hairy body. Mastodons were found in North America and are often confused with the mammoths (see supplemental file, Figure 4) even though they are extremely different (Shoshani, 1992; Shoshani, *et al.*, 1996; Lambert & Shoshani, 1998) (see supplemental file, Figure 5). Family Mammutidae went extinct without contributing to present day animals (see supplemental file, Figure 6).

There is sometimes confusion concerning Stegodontidae (see supplemental file, Figure 2) because it was once thought that they were the ancestor of Elephantidae. Similarities such as skeletal anatomies, skull formation, and grinding teeth morphology as well as the fact that stegodons were found in Africa gave rise to this belief. However, there is now proof that both of these families evolved in a corresponding manner from a stem gomphothere ancestor. Their evolution occurred during the late Miocene to early Pliocene epochs in Asia. The true elephants evolved in Africa. This and specific morphological features convinced experts that Stegodontidae were not the ancestors of Elephantidae (Shoshani, 1992).

Primelephas (5-7 million years ago; late Miocene/early Pliocene ages) means "first elephant" and is the oldest member of the family Elephantidae. *Primelephas* (see supplemental file, Figure 2) gave rise to the other three genera in this family, *Mammuthus* (containing seven species), *Elephas* (see supplemental file, Figure 7) (containing seven species), and *Loxodonta* (see supplemental file, Figure 8) (containing three species). Their trunks were somewhat larger than those of Gomphotheriidae with tusks in upper and lower jaws. They exhibited an increased number of ridges on their molars to grind up coarse vegetation. Genera *Elephas* and *Loxodonta* contain modern day Asian and African elephants.

The mammoth, *Mammuthus* (2 million to 8000 years ago; late Pliocene/early Holocene ages) was 3-3.7 meters tall, with colossal tusks and a hair-covered body, (Thomas, *et al.*, 2000; Joger & Garrido, 2001). Abundant well-preserved frozen carcasses of mammoths found in Siberia and Alaska have offered absolute confirmation of internal and external anatomical features of this extinct proboscidian. There are conflicting interpretations of molecular data related to the phylogenetic relationship of *Mammuthus* with regard to the other two genera (Thomas, *et al.*, 2000; Debruyne, 2001). Hagelberg *et al.*, (1994) and Hauf *et al.*, (1995) found a closer affinity of *Mammuthus* to *Loxodonta*, while Yang *et al*. (1997) and Ozawa *et al.*, (1997) found a common branch with *Elephas*. Without a doubt more research is needed to determine the phylogenetic connections of *Mammuthus* (see supplemental file, Figure 9).

Historically, the order Proboscidea contained 350 species, but at present, 3 Asian elephant and 2 African elephant species are all that remain.   Many factors have contributed to the extinction of the other species. Some have become too specialized and failed to adapt to changing conditions. We can only speculate about what took place, but we do know that natural selection dictates that an organism must be capable of adaptation or face extinction. Change is a certainty and the climate was changing rapidly at the time of these extinctions. A low reproductive potential undoubtedly would have added to their decline. Present day elephants are especially adaptive, since they are successful in many extreme environmental conditions. Such conditions span from forest to desert, from mountains to caves, and from frigid to sweltering temperatures (Shoshani, 1992). Elephants share their ability to adapt to diverse environments with their close relatives, Hyracoidea and Sirenia.

Superorder Paenungulata

Traditionally, scientists used fossil records to find commonality between present day individuals and those of the past. With new technology, however, it is possible to investigate relatedness on a molecular level (Lavergne *et al.*, 1995; Ozawa *et al*., 1997; Arnason, *et al.*, 2002). Results of such new techniques have confirmed previous findings that the order Hyracoidea is the closest living animal to the superorder Tethytheria (orders Sirenia and Proboscidae) sharing a common ancestor (Springer, *et al.*, 1997; Stanhope, 2001; Nikaido, *et al.*, 2003). The probable forerunner, *Moeritherium*, lived about 50 million years ago (Palmer, 1999).

Order Hyracoidea contains seven living species. Hyraxes are African rodent-like animals about the size of a rabbit (see supplemental file, Figure 10). A Maasai (tribe of North African peoples) legend refers to the Hyrax as “elephants little brother.” Like elephants and manatees, hyraxes lack a clavicle; their incisors are long and grow throughout their life; and they exhibit unique carpal bones, serially arranged so as to indicate one bone is in contact mostly or only with one other carpal bone above and below (see supplemental file, Figure 11).

All three orders, Hyracoidea, Sirenia, and Proboscidae, are strict herbivores. Amino acid sequences of the hemoglobin of these orders corroborate their relatedness, (Kleischmidt, 1986). Two other important shared features are an exceptionally long gestation period of about 22 months, and the lack of an external scrotum in males (Chance, 1996). Testicles are contained within the abdominal cavity like whales and dolphins. Such placement is common in marine mammals such as closely linked manatees however; hyraxes and elephants are the only land mammals with this unique arrangement. In all other mammals, the testes are external due to the destructive influence of high internal body temperatures on the sperm. Female elephants follow the typical mammalian pattern with sexual organs placed deep within the body and protected by a vestibule.

Suborder Tethytheria ("beasts of the Tethys")

Proboscidea and Sirenia (see supplemental file, Figure 12) are placed in a higher taxonomic group called Tethytheria. All Tethytheria possess a double-apexed heart, unlike other mammals that have a single–apexed heart (Mariappa, 1986). Further evidence in support of *Moeritherium* being the common ancestor shared by modern Proboscidea and Sirenia, is research which has revealed that, like *Moeritherium*, Proboscidea and Sirenia "lack the fenestra cochleae and aqueductus cochleae and instead, possess a secondarily undivided perilymphatic foramen" (Court, 1994; Fischer, 1990).

Order Sirenia contains manatees, dugongs, and the now extinct sea cow. Manatees have tough, grayish-brown, wrinkled skin that feels much like that of an elephant with toenails resembling an elephant's. A manatee's big nose is reminiscent of a short trunk, is used to grab plants and pull them into their mouth.

Cetaceans (other marine mammals) and sirenians differ in their diets. Sirenians are the only marine mammal alive today mammals that are strict herbivore. Their diet consists primarily of sea grasses and other aquatic vegetation. DNA, biochemical, and immunological data have shown that the elephant of today is most closely related to these aquatic mammals (Gaeth, *et al.*, 1999).

Many authorities consider these shared traits as morphological indicators of a recent aquatic past for proboscidians. Evidence supporting this notion is accumulating. It is an accepted concept that land animals can and did return to an aquatic environment. For instance, dolphins evolved from land dwellers, wolf-like animals of order Condylarthra (see supplemental file, Figure 13) (58 million years ago, Paleocene age) (Quayle, 1988). Conversely, to propose that early proboscidians (*Moeritherium*) came from a recent aquatic relative is to imply that after making a transition from land to water, they then returned to land. Such an evolutionary scheme is unique but in the case of early proboscidians, there is physiological evidence that suggests that they are an exception.

Placement of the sex organs deep within the body cavity of marine mammals protects from cold water as well as streamlining the body for more efficient movement through water (see supplemental file, Figure 14). Similarity in the body plan of proboscidians could be a persuasive vestige of life spent in water. Other morphological features that could support this evolutionary scenario are as follows:

1. The Apex of an elephant's heart presents two points instead of one like most other mammals (Mariappa, 1986). Sirenia and whales are the only other mammals having this unusual attribute.

2. Mammalian lungs are surrounded by two layers of thin membrane, which form the pleural cavity. Within the pleural cavity is a small amount of liquid called serous

fluid. However, in elephant lungs, a type of connective tissue that allows the tissue to slide over each other replaces serous fluid. This unique feature enables elephants to withstand the extreme differences in pressure above and below water without rupturing blood vessels in the lining of the lungs (Johnson, 1980).

3. Like many aquatic mammals, elephants have little hair.

4. Elephant skin, like the manatee skin, is creased and folded, creating channels that encourage water to pass over the surface with less resistance. This feature also prevents dehydration when out of the water by presenting less surface area to the environment and conserving water within the creases and folds (see supplemental file, Figure 15).

5. A recent study found that elephants have a funnel-shaped kidney duct called a nephrostome. Nephrostomes are found in aquatic vertebrates; other viviparous mammals have nephrostome (Gaeth, 1999).

6. An elephant's penis, like that of the marine mammals, is completely retractable into a special pocket within the body wall (Shoshani &.Eisenberg, 1982; Mariappa, 1986), providing a streamlining effect.

7. An opening in the nostrils has migrated dorsally, as with whales and other marine mammals; it emerges above the eyes (Mariappa, 1986). The elephant's neck is too short to allow them to breathe through their mouths while swimming, so the trunk is used like a snorkel to allow proper breathing. In addition, this attribute allows elephants to open their mouths and feed under water (Johnson, 1980).

8. As stated above, with the exception of the hyrax, elephants are the only land animals with internal testicles. Seals and whales also have this feature but only acquired

it after their land-living ancestors took to the sea about 60 million years ago (Riedman, 1990).

9. The elephant's diaphragm is oblique, as in whales and dugongs (Kellogg, 1925; Mariappa, 1986).

10. Elephants are among the finest swimmers of all terrestrial mammals and are known to swim hundreds of miles. They swim in a lunging, porpoise-like manner at speeds of 2.7 km/hr (Johnson, 1980; Gaeth *et al.*, 1999).

11. Unlike other mammals, elephant teeth do not fit into permanent sockets in the jawbone (see supplemental file, Figure 16). As the teeth wear out, the new teeth behind push the worn ones out of the jaw and take their place (see supplemental file, Figure 17) (Mariappa, 1986). Teeth are replaced approximately six times during a lifetime, making a total of twenty-four teeth (Shoshani &.Eisenberg, 1982). The only other mammal with this feature is the manatee.

12. Molecular, immunological, and shared anatomical and physiological characteristics demonstrate an extremely close affinity between the modern elephant and the aquatic Sirenia (Ozawa, *et al.*1997). This evidence indicates that some of their common ancestors must have developed into fully aquatic animals who later returned to land (Gaeth, 1999; Johnson, 1980).

By itself each of these physiological characteristics is not that convincing, but when all the evidence is considered, there is an accumulative effect which maintains the scenario that early proboscidians came from a recent aquatic relative and that after making a transition from land to water, they then returned to land. However exceptional this situation might seem, it is reasonable to support it as the evolutionary path the family Elephantidae followed to produce genera *Loxodonta* and *Elephas.*

Family Elephantidae: *Loxodonta* and *Elephas*

Family Elephantidae includes two living genera, *Loxodonta* and *Elephas*, the African and Asian elephants, respectively. Both genera evolved from *Primelephas* during the early Pliocene age in Africa. *Elephas*, however, migrated beyond Africa to the colder climates of Asia (Shoshani, 1992; Palmer, 1999). As the only remaining members of this family, they generally share similar physical and behavioral attributes (see supplemental file, Figure 18). The most defining feature of these herbivores is the extension of a fused upper lip and nose which forms a trunk (see supplemental file, Figure 19). This highly flexible appendage provides elephants with a multitude of abilities. Its versatility is the result of two kinds of muscles that make up more than 100,000 interlacing motor units (1,000,000 individual fibers) (Endo-Hideki, *et al.*, 2001).

They both have tusks (enlarged incisors), or tushes (specialized canines), large bodies, and mammary glands between the forelegs (Shoshani & Eisenberg, 1982). Neither genus has a gall bladder nor sternum, their tongue is fleshy and is attached in such a manner that it cannot be pushed outwards, and their eyesight is poor so they rely heavily on their keen sense of smell (Rasmussen, 1999). The word elephant is taken from the Greek meaning "ivory." Both Asian and African elephant females are smaller than males. With all their similarities they do maintain many significant differences.

These differences (genotypic and resulting phenotypic) were due to the natural geographical distribution of wild populations of Asian and African elephants. Taxonomy reflects their diversity by placing them in the same family but different genus and species. For illustrations of similarity among family members, the wolf shares its family with lions, tigers, bears and raccoons while humans with gorillas, chimpanzees (common and bonobo) and orangutans. Mating outside a species but within a genus is possible but offspring are usually sterile, as in the mule (cross between a horse and a donkey). Crossbreeding between genus was thought to be impossible, but on November the seventh nineteen seventy eight Motty was born at the Chester Zoo in England. Motty was the product of Sheba an Asian female and African male Jumbolina. Motty was born premature so lacked vigor. Sheba tended to her weak calf, often steadying him with her trunk until his death died 10 days after birth (Supplemental file, Figure 20). A necropsy presented necroticenterocolitis and E coli septicemia as the cause of death (Lyon, 1998) resulting from an underdeveloped immune system due to being premature. Motty's phenotype was a blend of characteristics from both genera. He exhibited an African elephant's cheek, ears and back, while the number of front and hind nails of the Asian as well as Asians single finger.

Asian elephants (*E. maximus*) weigh 2,000 to 5,400 kg. They have smaller ears and smoother skin than the African elephants, with more patches of de-pigmentation skin on their bodies. They also have two dome-like structures on the top of the head and one triangular-shaped dorsal "finger" at the tip of their trunk, making the trunk a decidedly versatile appendage (see supplemental file, Figure 21). The "finger" is packed with free nerve endings which "can be correlated with the tactile ability of these animals to use the trunk 'finger' to grasp small objects for feeding and to insert chemically active samples into the ductile orifices of the vomeronasal organ for subsequent chemosensory processing" (Rasmussen & Munger, 1996). Their bodies are smaller in size than those of African elephants, but are stockier in build with a convex or level back; their belly is almost horizontal or sags in the middle. They have 19 pairs of ribs (with the exception of the Sumatran sub-species which normally have 20 pairs) (Shoshani & Eisenberg, 1982). Asian elephants also differ from African elephants in having five nails on their front feet (see supplemental file, Figure 22) and four on the back, as well as the rings and structure of the trunk. Authorities on Asian elephants consider the three subspecies to be *Elephas maximus maximus* (Sri Lankan elephants), *Elephas maximus indicus* (Indian & Indochinese elephants), and *Elephas maximus sumatranus* (Sumatran elephants).

African elephants are tall gangly animals which weigh up to 6,000 kg. They have 21 pairs of ribs, a concave back, and a belly that slopes diagonally downwards from front to back. Their ears extend beyond the top of their head and are three times the size of Asian elephant ears. Their skin is heavily wrinkled and rarely has de-pigmentation patches. Unlike the Asian elephant, both males and females have tusks. They possess one dome on the top of the head, with two fingers on the apex of their trunk. The surface of their teeth has diamond-shaped ridges instead of the parallel ridges of the Asian elephant, and they bear five nails on the front feet and three on the back feet (Laursen & Bekoff, 1978).

Until recently, it was believed that all populations of African elephants were the same genetically, but there is a clear difference between the species *L. cyclotis,* a forest dweller, and *L. africana,* a savanna dweller. The disparity between these two elephants is comparable to that of the lion and tiger (Roca*, et al.*, 2001).

The genesis of the differentiation between these two species of African elephants was 2.63 million years ago. The savanna elephant has large ears and curving ivory tusks, while the forest elephant is smaller, has round ears, and has tusks that are slightly pink, straighter, and longer. All savanna elephants are similar genetically, indicating gene flow between herds, which is consistent with their roving male breeding system. Forest elephants are genetically different from one another, and rarely mate and reproduce with members of other forest herds, opening the door to the possibility of these forest herds becoming species of their own.

As far as behavior is concerned, both genera of elephants are highly intelligent herd animals and have very similar lifestyles (Fernando & Lande, 2000b). The African elephant is considered more difficult to domesticate than the Asian elephant. This could be because the Asian elephant has been in the service of humans for centuries, while African elephants generally have not been domesticated. All species in both genera live in matrilineal societies usually led by the oldest female. Each herd is made up of the matriarch and her female family members. African elephant calves (under the age of 2) are unlikely to live if their mother dies even if other members of the herd care for them, while Asian elephant calves 18 months old usually survive. Calves are usually weaned after they reach two years of age (Gadgil & Nair, 1984). When male calves reach puberty, they leave their mother's herd and join other young males in bachelor groups. Older males tend to be solitary.

Present Day Elephant Population in Asia

The Harappan seal from 3500 years ago found in northwestern India as well as cave paintings in other areas of India depict domesticated or trained elephants at around

6000 B.C. Implications from these drawings are that Asian elephants have been joined with man for a 5000 to 8000 year span (Lahiri-Choudhury, 1995). In spite of a small percentage of domesticated elephants during this period, elephants flourished in the wild.

Present day wild populations of Asian elephants (*Elephas maximus*) are on a steady decline numbering between 37,530 and 48,180 years ago (Keele, 2001). Habitat destruction and population fragmentation are responsible for these diminishing numbers (Keele, 2001). These two factors compel elephants to journey long distances toward safe feeding grounds. Energy expenditures such as these are costly for them due to their extremely inefficient digestive system. How animals use their energy is of prime importance to their survival in the wild. An activity time budget study of the Asian elephants at Idukki Wildlife Sanctuary in Kerala, India by Vinod and Cheeran (1997) demonstrates the importance of not only the amount of habitat available to elephants but also the type (McKay, 1971). Feeding accounted for 65.0% of the activity in the dry season and 81.0% in the wet. Grazing was predominant in both dry (64.0%) and wet (71.0%) seasons, indicating the significance of grasslands for the preservation of this species (Vinod & Cheeran, 1997). So conservation efforts will not only have to emphasize preserving enough space for them but also the type of environment they have access to.

As habitat shrinks and human numbers increase, elephant and man are squeezed into closer proximity (Norris, 1959). The human population in India has doubled in the past 20 years (Santiapillai, 1990) making conservation efforts and establishment of elephant reserves extremely difficult and more of a major socio-economic matter. Lahiri-Choudhury (1990) speaks for those who demand a resolution for this dilemma when she states the philosophy must change to an adjustment between the needs of wildlife and environment, and needs of man, particularly people in the fringe areas dependent on forest resources for their subsistence. (Norris, 1959; McKay, 1971; Santiapillai, 1990) Habitat destruction and population fragmentation cause another difficulty to survival of the species and will eventually result in inbreeding within isolated herds (Keele, 2001) losing the genetic diversity needed to insure their long-term survival (Nozawa & Shotake, 1990).

Reproductive and Social Behavior of Asian Elephants in the Wild

The decidedly social female Asian elephant resides in a hierarchical society (Gadgil & Nair, 1984; Garai, 1992; Schulte, 2000). The matriarch, her sisters, and their offspring comprise the family grouping (Rasmussen & Schulte, 1998; Hutchins & Smith, 2001) which develops and maintains deep-seated, lifetime bonds (Garai, 1992; Payne, 2003). The matriarch attains a learned expertise concerning her environment and other survival strategies from elders in her herd (Gadgil & Nair, 1984; Poole *et al.*, 1997; Payne, 2003). She uses this heritage of acquired understanding to direct her charges to food, water, and safety (Nair, 1989; Hutchins & Smith, 2001; Payne, 2003).

In many of the more highly intelligent animals, social and survival behavior appear to be learned. Elephants adhere to this archetype (Eisenberg, *et al.*, 1971; Gadgil & Nair, 1984; Poole *et al.*, 1997). A characteristic of intelligent animals is the ability to make and use tools. Those who have had occasion to observe elephants in their natural surroundings have reported seeing them fashion a switch from branches to repel flies

(Hart & Hart, 1994; Reid, 1998). Such ability is not surprising considering elephants have a particularly large cerebral cortex. This area of the brain is utilized for cognitive functions. In fact, the volume of their cerebral cortex exceeds that of great apes. This puts elephants in the same category of cognitive processing as primates, (Hart, *et al.* 2001). Speculation as to the reason why elephants developed this ability is that it was an adaption to repeal ectoparasites (Chevalier-Skolnikoff, & Liska, 1993). Creating tools is a skill passed from one generation to another.

The young discover appropriate provisions and necessary gathering skills by watching experienced elephants harvest food from their environment. They acquire a taste for proper "elephant foods" by eating what the others are eating, sometimes taking food out of their mouths (Nair, 1989; Payne, 2003). Calves also learn to stay near their mother to avoid dangers, such as predators and mud flats (Nair, 1989). Juvenile females also learn correct responses to attentive males by watching the mature females during mating (Eisenberg, *et al.*, 1971). Such observations quickly instruct young cows that breeding attempts by related adolescent males are not acceptable (Eisenberg, *et al.*, 1971; Payne, 2003). Amorous conduct by adult males toward immature females meets with a negative response from dominant females, instructing youthful males and females that such behavior is prohibited (Eisenberg, *et al.*, 1971). Adolescent females also gain knowledge of birthing as well as mothering by watching births and tending to younger siblings and cousins (Gadgil & Nair, 1984).

Unlike females, males live a solitary life style. As they reach sexual maturity, older females banish them from the herd (Eisenberg *et al.*, 1971; Rasmussen *et al.*, 1993). This is behavior frequently observed in nature to prevent inbreeding (Alcock, 2005). Adolescent males often join bachelor herds in which they may remain throughout their teens and early twenties (Eisenberg *et al.*, 1971; Schulte, 2000; Keele, 2001). Once the males have reached maturity they experience a phenomenon called “musth” (Eisenberg *et al.*, 1971; Cooper *et al.*, 1990; Rasmussen & Schulte, 1998; Duer, 2004). This period is characterized by a loss of appetite, drainage from the temporal glands (see supplemental file, Figure 23), urine dribbling (see supplemental file, Figure 24), and increased aggression and elevated serum testosterone concentrations (Cooper *et al.*, 1990; Lincoln & Ratnasooriya, 1996; Dickerman *et al.*, 1997; Rasmussen & Schulte, 1998; Duer, 2004).

There are those who promote the belief that “musth” provides an episode in which males scent-mark their territories and possibly fight other males for mating rights to the females within these territories (Cooper *et al.*, 1990; Rasmussen & Schulte, 1998). “Non-musth” males avoid males in “musth,” thereby eliminating them from breeding competition (Rasmussen & Schulte, 1998). Once males mature, they are solitary except when courting an estrus female (Rasmussen *et al.*, 1993, Rasmussen & Schulte, 1998; Keele, 2001; Payne, 2003).

The elephant’s proboscis serves as an indication to the importance of smell in their every day existence. As in many species chemocommunication is used to indicate physical condition, location, as well as reproductive status (see supplemental file, Figure 25) (Rasmussen *et al.*, 1982; Rasmussen *et al.*, 1993; Rasmussen, 1998; Rasmussen & Schulte, 1998; Rasmussen, 1999; Riddle *et al.*, 2000; Lamps *et al.*, 2001; Rasmussen & Wittemyer, 2002). Chemical messengers can be expressed from urine, feces, urogenital openings, temporal glands, inter-digital glands, breath and ears (Rasmussen &

Krishnamurthy, 2000; Riddle *et al.*, 2000; Rasmussen & Wittemyer, 2002). Male elephants assess a female's receptiveness by way of a modified flehmen response to urine, feces, and the urogenital opening utilizing their vomeronasal glands, which are twin orifices located in a small recess in the dorsal anterior part of the mouth (Diephuis, 1993). As females reach the pre-ovulatory state, they release pheromones that signal males of their impending estrus (Rasmussen *et al.*, 199a; Rasmussen *et al.*, 1996b; Rasmussen, 2001). For years researchers speculated about the existence of a pheromone that females might emit to indicate their reproductive state (Eisenberg *et al.*, 1971). A pheromone ((Z)-7-dodecen-1-yl acetate) commonly found in126 species of female insects as part of their pheromone blend to attract males was recently determined to be in estrus pheromones of female Asian elephants (Rasmussen *et al.*, 1996a; Rasmussen *et al.*, 1997).

Males also release pheromones signaling their "musth" status (Rasmussen & Perrin, 1999). There is a high correlation between the number of matings and the occurrence of "musth" in natural settings (Perrin *et al.*, 1996; Rasmussen *et al.*, 1996b; Rasmussen, 1999; Rasmussen & Perrin, 1999; Schulte & Rasmussen, 1999). Females exhibit preferential mating with dominant musth males and evade non-musth males or related males in an effort to avoid mating with them; however copulation and conception can take place even when the male is not in "musth" (Poole, *et al.*, 1997; Rasmussen & Schulte, 1998).

Another preeminent physical feature of the elephant is their ears. In addition to the function of cooling and warming their blood, elephants' large ears are capable of extremely sensitive hearing over great distances. An additional type of communication used by elephants is an intricate system of infrasonic calls (Payne *et al.*, 1986).

Infrasonic communication occurs in frequencies below the range that humans can hear (approximately 20 to 20,000 Hz). The daily lives of elephants require that they communicate with one another over long distances as well as in close proximity to maintain unity within a herd, to preserve cohesion among different herds, to advertise reproductive status, and to locate mates (Garstang *et al.*, 1995; Larom *et al.*, 1997; O'Connell *et al.*, 1997; Payne, 1997; Byron *et al.*, 1998; O'Connell-Rodwell, 2000). Chemocommunication and infrasonic calls are used primarily over long distances while vision, touch, vocalizations, and chemical signals are used in short-distance contact (Gadgil, *et al.*, 1985; Payne *et al.*, 1986; Langbauer, 2000; Payne *et al.*, 2003).

African elephants exhibit a variety of sequential patterns associated with reproductive vocalizations, from a pre-ovulatory estrus call by the females to bantering between males and females at estrus (Leong *et al*., 2003 a, b; Payne, 2003). Male elephants have been known to signal their "musth" status with a "musth rumble" (Pool, 1999; Payne, 2003). In playback experiments, "musth" males would approach this call, while "non-musth" males would leave the area (Poole, 1999). Elephants are even known to produce seismic signals that can travel great distances through vocalizations, foot stomping, and locomotion (O'Connell *et al.*, 1997; Arnason *et al.*, 1998; O'Connell-Rodwell, 2000). Seismic communication is often associated with infrasonic calls (O'Connell *et al.*, 1997; Arnason *et al.*, 1998; O'Connell-Rodwell, 2000).

Summary

Chapter I has provided a knowledge base that establishes a clear understanding of the origin of elephants, their life style, social structure and physical make-up. This information will enhance comprehension of upcoming chapters and enable a better grasp of topics that will be discussed. Now that the subject of this study has been scrutinized it is time to look at the institutions that house confined animals.

CHAPTER II

ACCOUNT OF ANINIMALS IN CAPYIVITY AND MANAGEMENT OF CAPTIVE ASIAN ELEPHANTS (ELEPHAS MAXIMUS) IN NORTH AMERICAN ZOOS

CHAPTER RATIONALE

Chapter II will introduce the establishments that house captive animals, the history and management of animals, and the organizations that govern these institutions. Elephant husbandry and reproduction are clarified and problem issues are addressed.

History of Zoos

Pre and Early Zoo History

Mankind has always held a fascination for animals. Early man's existence depended on an ability to observe his environment and implement necessary survival strategies. As man evolved, his focus changed from that of merely surviving to one of domination of his world and the animals in it. Enhanced cognitive abilities coupled with an appropriate body plan allowed him to not only thrive within his environment but also change it for his benefit. Domestication of plants and animals allowed civilization to burgeon. The influence of progress upon other living things was more often than not detrimental. Even so, as man's dominance was established and his primordial competitors slipped into near or total extinction, he became increasingly conscious of their significance to his fundamental nature (Murry, 1993).

When there is a need there is usually a resolution, thus the concept of collecting wild animals. Within the safety of a civilized institution, people could scrutinize the unusual and sometimes fearsome occupants of the wilds. Young (2003) suggested two rationales for such collections. First, many collected species had religious significance. Secondly, possession of exotic animals was considered a status symbol. This paradigm is observed by different cultures in many variations and settings throughout history (Hoage & Deiss, 1996).

"Animals were probably more thoroughly involved in the culture of ancient Egypt (3000 B.C.) than in any other" (Bostock, 1993), so much so that images of Egyptian gods were often part animal part human. They regarded many animals as sacred. Snakes and bulls represented the sun and primordial creative force (Mullan & Marvin, 1987). Hippopotamuses, owls, crocodiles and scarab beetles are examples of other animals revered by Egyptians (Bostock, 1993). Such regard for animals may provide the rational for Egyptian people's cohabitation and intermingling with animals and for why the Pharaohs chose to cohabitate with exotic beasts. Rameses II kept his favorite lion, Antam-nekt, close to him at all times. It sat beside his throne, walked beside his chariot, and even fought beside his Pharaoh.

The earliest images of animal keeping (2495-2345 B.C.) are found lining the tomb of an affluent Saqqaraian nobleman (Bostock, 1993). Oryx, addax, gazelle, geese, and hyena are clearly identifiable, leaving no doubt that they were being held in reserve by the peoples of Saqqara (Lauer, 1976). These renderings suggest that the animals portrayed were in all probability domesticated to some extent.

In Mesopotamia, during the third dynasty of Ur (2094-2047), the Palace grounds of Great King Shulgia provided evidence of what is believed to be the earliest zoo 1000 years before Jesus lived (Croke, 1997). Clay bookkeeping tablets were found with journal entries of receipt and distribution of thousands of animals, domestic and exotic.

The Harappan seal found in northwestern India as well as in cave paintings in other areas of India depict domesticated or trained elephants around 6000 B.C. Implications of these drawings are that Asian elephants have been working with man for 5000 to 8000 years (Lahiri-Choudhury, 1995).

To the East in China around 1150 B.C., the “Intelligence Park” (Croke, 1997) or “Park of Knowledge” (Hoage & Deiss, 1996) was constructed in honor Emperor Wen Wang in the province of Henan. Wen Wang was so esteemed by his people and his park so remarkable that philosopher Mencius wrote an elegy commemorating its creation (Croke, 1997). The Park of Knowledge contained “at least two kinds of deer, a variety of birds and an enormous quantity of fish (Hoage & Deiss, 1996). Other Emperors pursued this practice after Wen Wang’s death.

King Solomon (mid tenth century B.C.) was also believed to have a collection of exotic animals sent to him as tributes or gifts from many nations, as was the custom among rulers (Hoage & Deiss, 1996). Old Testament writings spoke of two lions standing on either side of Solomon’s throne with twelve lions standing on both sides of his throne room. “There was not the like.... in any kingdom (Bible).” Other passages spoke of Solomon keeping and breeding a variety of animals, including horses, and receiving apes and peacocks by ships (Bible, Hoage & Deiss, 1996).

Ancient Greeks were the first to require people to pay to see the animals within a menagerie and bring school children there as part of their education. They also had traveling animal shows as well as exhibiting animals associated with their religious practices near temples (Hoage & Deiss, 1996). Ptolemy I (323-285 B.C.), a naturalist, founded a spectacular zoo in Alexandria. Ptolemy II (285-246 B.C.) expanded the zoo to equal the great library there (Hoage & Deiss, 1996). During the Feast of Dionysus (285 B.C.) he orchestrated the largest parade of animals in history. It lasted the biggest part of a day and contained 96 elephants, 24 lions, 14 leopards, 14 oryx, 16 cheetahs, 14 wild asses, and hundreds of domesticated animals (Hoage & Deiss, 1996).

As early as 186 B. C. Romans used animals in blood-letting games. They had holding areas called vivaria, which were connected to arenas where animal-animal or man-animal conflicts would occur. Animals such as leopards, lions, hippopotamus, ostriches, oryx, and crocodiles from Africa; bear, bison, elk, and tigers from Asia, as well as elephants from both Asia and Africa were used in their fight-to-the-death sports (Hoage & Deiss, 1996).

Two outstanding animal collectors lived during medieval times. In Europe Frederick II (1194-1250) King of Sicily, Holy Roman Emperor was not only a statesman but also a published naturalist. He established marshes and ponds fed by aqueducts and populated with diverse species of waterfowl. Frederick II's interest in animals went beyond collecting. He was a true scientist and studied ecology, behavior, and anatomy. His publications were a book about falconry and an introduction to ornithology. Under his direction Michael Scot, court astrologer, translated Aristotle's zoological works from Arabic to Latin (Bostock, 1994). During the late Bronze Age, Honoree Emperor Wen-Wang of China created his renowned "Intelligence" or "Knowledge" Park. Two thousand years later, in 1298, Marco Polo described the extraordinary deer parks (or animal parks, until 1490 the word "deer" meant "animal") of Kublai Khan, Mongol Emperor of China. Kublai Khan, like Frederick II, hunted with falcon, and rode with a cheetah on the back of his horse, which he would release to catch prey. Khan also hunted with leopards, lynxes, and tigers. It was said that a tame lion was sometimes led into Kublai's presence and would prostrate itself before him, and stay there without restraint. His vast parks were watered by springs and streams and housed free-roaming white hart, stag, musk deer and roebuck as well as ponds stocked with all manner of fish. Kublai Khan was also interested in fauna and had plants and trees transplanted to his extraordinary parks (Bostock, 1993).

In 1519 Cortes and his army entered Mexico City to find a splendid zoo. Montezuma had constructed extraordinary gardens, housing for the vast array of every manner of beast, ponds for aquatic creatures, and hundreds of workers to attend to the flora and fauna (Hoage & Deiss, 1996; Nichols, & Michael, 1996). Also in the fifteenth century Pope Leo X of Medicis (1513-1523) enlarged the Vatican menagerie to include lions and leopards from Florence, bears from Hungary and a particularly notable elephant from King Manuel I of Portugal (Bostock, 1993). Bostock chronicles the episode "The Portuguese ambassador, the elephant and everything else (a snow leopard, tapestries, jewels and a magnificent Arab horse) on arrived on 12 March 1514. At the window where sat the Pope and court, the elephant stopped, obediently knelt three times to render homage to His Holiness, and then decided the crowd was a bit too pressing. He noticed a nearby tub of water, plunged in his trunk, and everybody from the Pope downwards got squirted. Leo was vastly amused" (Bostock, 1994). According to the account, the elephant remained a celebrity with the people and was immortalized by painters and poets of the day (Bostock, 1994).

Other examples of premier animal collectors are Charlemagne, King Henry I of England, Philip of France (twelfth century), who established menageries in Europe, and Louis XV (1665) who kept a menagerie in Paris which housed 222 species of living creatures. These "menageries" were created exclusively for the amusement of the aristocracy, unlike today's zoos that cater to the general public.

Modern Day Zoos

Contemporary zoos, in which animals are kept on exhibit for public viewing, emerged in the late 1700's and early 1800's in Europe (Nichols, & Michael, 1996). Enclosures were established in large airy settings much like a garden. Visitors would walk leisurely through this contrived scene viewing the animal collection; consequently its designation as a "zoological garden" (a garden of animals).

America's first zoo was established at Philadelphia in 1859 and was modeled after London's Regent's Park Zoo (Hoage & Deiss, 1996). Soon to follow were New York's Central Park (1860's) and Buffalo Zoos (1870's) and Chicago's Lincoln Park Zoo. In 1889, the Congress of The United States legislated the establishment of the National Zoo in Washington D.C. with its mission being the "advancement of science and the instruction and recreation of the people" (Nichols & Michael, 1996).

The operations of these zoos were directed towards attracting patrons and acquiring as many different and popular animals as possible. Attendance was their number one priority; the needs and well-being of their captives was not a pressing issue. If an animal became sick or died, a new one was taken from the wild to replace it.

Specimens in the collection were housed individually in separate cement cages with bars on the front. These cages were easy to clean and allowed the public to see the animal. It was not until the 1970's that man came full circle to question these inhumane practices and zoos across the country began revising their mission statements.

In response to heightened public awareness concerning animal rights, zoo administrators began the process of restructuring not only their facilities but also animal care and each zoo's mission (Mench, & Kreger, 1996; Hediger, 1964).

Differentiation of "Animal Rights" and "Animal Welfare"

Within most controversial issues, terminology becomes a major dynamic. In order to generate a constructive dialog, both factions must agree on the meaning of key terms. Therefore, for purposes of clarity and instruction, a distinction between the terms "animal rights" and "animal welfare" is required before proceeding.

One might suppose that the current trend in "animal awareness" is a product of our highly-evolved conscientiousness but the truth is that as early as 1927 passionate books were being written mirroring the same concerns we observe today. Ernest Bell (Bell, 1927) published a controversial collection of articles gleaned from the preceding 25 years of the publication, *Animals' Friend*. *Animals' Friend* was an English magazine dedicated to disclosing man's influence on the plight of animals in the world. In the preface he writes, "Though the actual incidents commented on may be long past and over, they could, I much regret to say, be easily matched by parallel cases occurring almost every day and the old so-called 'arguments' in defense of the various forms of cruelty are the same today as were advanced by the transgressors in past years, and need refutation as much as ever they did."

Bell's reference to "fair treatment for animals" has given way to the contemporary expressions "animal rights" and "animal welfare." Though these two terms may appear to represent the same concepts, upon examination they actually convey very different implications.

Welfare is defined as the state- of- being in which one is thriving particularly in regard to good fortune, happiness, well-being, and/or prosperity (Mish, 2004). For our purposes, the animal's state of well-being is the primary issue (Crockett, 1998). It is assumed that good fortune, happiness, and prosperity are present in an animal exhibiting a sense of well-being. Progress towards insuring animal welfare is dependent on the agreement of responsible parties as to the description of well-being. Accurate protocol for assessing an individual's status must be a priority with an appreciation of the fact that these states are unique for not only each species and population within that species (Kistler, 1967) but also every individual within those sets (Fox, 1980; Barber, 2003). Such protocols can provide information that can be utilized to rate an individual's state (Barber, 2003), creating a method of evaluation and lending a more scientific influence to a topic which could be chaotic (Carlstead, 1999).

Rights are defined as 1. something to which one has just claim; 2. the power or privilege to which one is justly entitled, (Mish, 2003). This is the area in which there are more divergent views. They range from "man has dominion over the animals and can do as he sees fit" to the idea that animals and humans have the same rights and those rights must be protected (Kirtland, 2002). Rights issues have left the discipline of science and are being played out in courts throughout the country. Contrary to what might be expected of a group advocating “animal rights,” some of these factions believe that species have the right to go extinct and work against those who are trying to preserve endangered species. Never mind that man is responsible for the conditions causing loss of species. These groups protect man’s arrogant belief that he has the right to dominate the Earth and its inhabitance while concealing their intent in politically correct jargon that advocates “animal rights.”

Professional persons involved in animal care are looking at both of these matters with concern. The American Association of Zoological Parks and Aquariums (AZA) is actively engaged in reinventing life for animals in captivity by compelling member institutions to implement behavioral and environmental enrichment programs as well as encouraging research in all areas of animal care and management (Hutchins, 2001). It was for this purpose that the American Association of Zoological Parks and Aquariums (AZA) were formed.

History and Formation of the American Association of Zoological Parks and Aquariums

In 1924, the American Association of Zoological Parks and Aquariums (AZA) were formed in partnership with the American Institute of Parks and Executives (AIPE). At that time most zoos and aquariums were managed by local parks departments and “were little more than menageries or botanical gardens with exotic animals” (AZA web site, 2006). Their objective was to offer a specialized medium for zoo and aquarium professionals to exchange information in order to define key concepts and unify their acceptable implementation for all member institutions. AZA left AIPE in 1966 to become a branch of the newfound National Recreation and Parks Association (NRPA).

Times were changing and so was the public's perception of the world and the creatures with which they shared it. Viewing animals pacing in small barred cages was becoming difficult for a more educated public to accept, much less enjoy. In the fall of 1971, the AZA filed its charter to sever ties with NRPAT. On January 3, 1972 the Executive Office was opened, and on January 19, 1972 AZA was incorporated.

Guided by innovative zoo professionals who were willing to utilize their skills to fashion a "new Zoo" the AZA has committed its efforts to quality animal care, animal welfare, conservation of animals and their native environment, education of the public, and joint efforts in research which will inspire respect for animals and nature (Hutchins, *et al.*, 1978'; AZA web site, 2006). With that mission as their objective members of AZA are now required to provide a behavioral enrichment program as well as a systematic way to analyze the effectiveness and safety of environmental enrichment apparatus and techniques for animals housed there. Facilities that fail to comply with this requirement cannot be AZA accredited nor can they deal with any AZA accredited zoos. For this reason elephant groups in every zoo in North American has had to rethink their elephant management protocol.

North American Asian Elephant Population

In 2991, the North American captive population of Asian elephants numbered 24 males and 131 females (Keele, 2001). In the early 1980's AZA implemented a cooperative breeding program based on a collection of guidelines called the North

American Species Survival Plan (SSP) (Hutchins & Smith, 2001). The SSP mission is Plan (SSP), (Hutchins & Smith, 2001). The SSP mission is to direct the efforts for the conservation and management of elephants in North American, (Keele & Dimeo-Ediger, 1999). Genetic makeup (Bischif & Duffield, 1994), age, health, and transportation considerations (Minion, 2001) of the captive population are used to determine annual breeding plans for AZA members. Recommendations can be for either temporary breeding loans of females to institutions with genetically complimentary males or artificial insemination (Bischif & Duffield, 1994). Transporting adult males for temporary breeding loans is not practical because of their size and aggressive nature. Since 1962, fewer than 100 calves have been born (Keele & Dimeo-Ediger, 1999; Faust *et al*., 2005). Of calves produced, there has been less than 30 percent mortality due to stillbirth or death of infants within 30 days of birth (Kurt & Mar, 1996; Keele & Dimeo-Ediger, 1999; Faust *et al*., 2005).

Within the SSP population there has not only been a serious decline in the number of calves born but also a decrease in the number of committed participants (Sheny, *et al.*, 1994; Keele & Dimeo-Ediger, 1999; Schulte, 2000; Wiese, 2000; Faust *et al.*, 2005). This lack of cooperation has contributed to the prediction of a population crash within thirty years. Only a renewed dedication by non-participating institutions will enable the founder population an opportunity to rapidly contribute offspring (Keele & Dimeo-Ediger, 1999; Faust *et al.*, 2005).

The waning captive population is also plagued with other obstacles. Some of these difficulties are linked to a depleted reproductive rate (Hutchins & Smith, 2001). The existing fecundity rate is approximately 1-2% while the projected requirement for a viable captive population is 7-8% (Hutchins & Smith, 2001). Fundamental causes for this minimal fecundity rate are due to an inability or failure of either the male or female to breed, infertility, or even the high proportion of facilities having only females. Another issue is loss of a fetus once conception has taken place because of fatal dystocias, resorption of the fetus, or the retention of the fetus in utero (Rasmussen *et al.*, 1982; Sukumar *et al.*, 1997; Hildebrandt *et al.*, 1998; Hutchins & Smith, 2001 Duer, *et al.*, 2002). Some of these difficulties may be centered in the complex social system Asian elephants experience and place additional importance on proper management of captive elephants (Carlstead & Shepherdson, 1994; Lindburg & Fitch-Snyder, 1994).

Husbandry of Asian Elephants in North American Zoos

Aggressive, solitary temperaments make male Asian elephants challenging and costly for institutions to sustain (Sukumar, 1991; Ruhter & Olsen, 1993; Taya, 1993). Their temperament, physical strength, and imposing size demand fortified structures to safely accommodate their particular requirements (Cooper et al., 1990; Sukumar, 1991; Lincoln & Ratnasooriya, 1996). Those who manage them classify elephants as hoof stock, but they obviously require specialized handling techniques (Cooper et al., 1990). Presently the accepted method of handling adult male Asian elephants includes hydraulically operated doors and chutes when it is necessary to move them from one enclosure to another (Hutchins & Smith, 2001). Many institutions also have constructed elephant restraint devices, a variation on cattle restraint chutes, to safely provide essential care (see supplemental file, Figures 26 & 27) (Hutchins & Smith, 2001). Owing to the hazards involved and expense of housing adult male elephants, few institutions in North America currently house males (Czekala *et al.*, 1992; Hutchins & Smith, 2001).

Females are normally less dangerous and less expensive to care for in captivity. Their natural inclination is to adapt to a social environment and be much more accepting of human and conspecific encounters (Hutchins & Smith, 2001). Such flexibility permits many institutions to accommodate herds of females in one enclosure. This cost-effective method for displaying females makes housing females more attractive to facilities than housing males (Hutchins & Smith, 2001).

Although most females are more biddable than adult males, there are exceptions to the rule. Some females may not assimilate well into a herd environment or may not accept new individuals, whether human or elephant. Most Asian elephants in North America today were wild-caught in Asia, transported here when very young and then placed in herds of unrelated females, creating an unnatural circumstance (Maberry, 1962; Keele & Dimeo-Ediger, 1999; Schulte, 2000). The outcome was a flood of very young animals into North America with no older females to supervise and instruct them in necessary life skills. There was no instruction by herd elders in what was appropriate to eat, how to develop and maintain stable herd structures, reproductive behavior or nurturing skills for rearing offspring (Nair, 1989; Fernando & Lande, 2000b; Hutchins & Smith, 2001). Inadequate nurturing has produced adult animals that lack the necessary abilities to successfully integrate into a herd, reproduce, care for their own offspring, or even foster other infants born into the group (Poole *et al.*, 1997; Sukumar *et al.*, 1997).

When facilities not able to house a breeding male decide to breed one of their females, they must manage not only the logistics of moving her but also the many problems associated with such an undertaking. Absence of the basic learned natural behaviors has produced an additional complication when dealing with a distressed female's ability to cope with transportation to a bull-holding facility (Minion, 2001). Managers must make the decision primarily based upon records of past experience relating to behaviors associated with transportation, herd integration, and acceptance of new handlers. By way of example, in many cases a new female may not be capable of integrating into another herd at a new location and may be forced to remain with the male as her only companion, creating an unnatural, stressful state for the female. Additional stress associated with being transported to a new facility has caused females to become acyclic, thwarting possible breeding attempts (Hutchinson & Smith, 2001). Further study of these potentially stressful situations would be useful and may be possible utilizing measurements of cortisol concentrations in saliva (Foley *et al.*, 2001). Lastly, it is necessary to assess the female's ability to leave her herd and then successfully re-integrate back into this herd once returned to her home facility.

Females with more aggressive tendencies must be carefully evaluated to insure the safety of the elephant handlers at the breeding institution. There are two basic recognized types of elephant management systems in captivity: "free contact" and "protected contact" (Wiedenmayer, & Tanner, 1995; Doherty, 1997; Hutchins & Smith, 2001). Free contact allows the handlers to enter the enclosure without barriers separating them from the animals for their care giving (Doherty, 1997; Koester, 2002), whereas protected contact requires that the handlers maintain a barrier or have a restraint between themselves and the animals (Bullock, 2000: Kinzley, 2000; Koester,I., 2002). Each system has its own advantages, balancing animal care and human safety (Kinzley, 2000).

These systems are not interchangeable and it is very difficult to move an animal accustomed to one management style to another without prolonged training periods for the adjustment (Bullock, 2000; Schanberger, 2000). Adult males are virtually all managed with some form of protected contact for the safety of the males and their human handlers (Doherty, 1997; Schanberger, 1994). Although the SSP committee is trying to coordinate the elephant population so that females will not have to alternate between management styles, they recognize that with the limited population, they may not be capable of totally segregating these two populations (Sheng, & Haight, 1994; Hutchins & Smith, 2001).

Meeting the Challenges of Captive Breeding

Natural behaviors are always preferred (Slade, 1903). This is especially true when breeding captive animals in unnatural settings. Elephants are no different, but the lack of institutions that are capable of accommodating males transfers an excessive burden onto the few establishments that have developed the facilities and staff to manage them (Maberry, 1962; Balke *et al.*, 1988; Hutchins and Smith, 2001). To sustain the captive population, those few institutions must maximize their breeding outputs and genetic diversity based on SSP recommendations. The rapidly aging elephant population in North America has created the necessity to breed these females soon in order to preserve their individual genetic input into the gene pool and to stabilize the age structure of a declining captive population (Keele and Dimeo-Ediger, 1999).

Recent research has shown that hormone levels play an essential role in reproductive behavior, thus increasing reproductive success (Dickerman, *et al.*, 1997;

Schulte and Rasmussen, 1999b). Males with elevated testosterone levels tend towards an increase in territorial defense and breeding behaviors (Dickerman *et al*., 1997); likewise females with increased estrogen levels tend to seek out and accept mating (Czekala *et al*., 1992). Hormones are also used to monitor the estrous cycle. This reproductive evaluation of females is crucial to the success of a breeding program (Brown, 2000). Progesterone concentrations are examined to evaluate her reproductive status and potential for breeding success (McNeilly *et al*., 1983; Plotka *et al*., Carden *et al*., 1998; Brown, 2000).

The more dangerous temperament of adult male elephants often causes managers to decide not to house these aggressive animals (Sukumar, 1991; Hutchins & Smith, 2001). The shortage of suitable housing for new males has become one of the leading problems in captive elephant management (Ruhter & Olsen, 1993; Keele and Dimeo-Ediger, 1999; Hutchins & Smith, 2001). Unfortunately, many successful breeding institutions have now suspended their breeding programs due to a shortage of suitable housing for male elephants that might be produced. This trend only intensifies the problem of a declining captive population (Hutchins & Smith, 2001). Recently, researchers have reported that the gender of an elephant calf in utero may be determined by analysis of total testosterone concentrations in maternal serum or progesterone concentrations (Duer *et al*., 2002; Duer *et al*., 2005). This information has assisted managers in making decisions for future breeding based on their institution's current gender ratio, including calves in utero (Duer *et al*., 2002; Duer *et al*., 2005). The use of sorted elephant sperm in artificial insemination to predetermine the gender of the calves before conception is a logical alternative to the natural 50:50 gender ratio produced, but this technique has not been developed.

Although artificial insemination has been developed for both the African and Asian elephant (1998 and 1999, respectively), the conception rate in African elephants has been much higher (Hutchins & Smith, 2001). Artificial insemination techniques in both species require intensive training and cooperation of the humans and elephants involved (Hutchins & Smith, 2001; Schwammer *et al.*, 2001). These methods require very stringent protocols and laboratory staffing, which most institutions do not have (Hutchins & Smith, 2001). Couple this lack of resources with low conception rates (partially due to problematic semen storage and difficulties in accurate semen deposition), and artificial insemination is an unlikely solution for the declining population of captive Asian elephants (Keele & Dimeo-Ediger, 1999; Kitiyanant *et al*., 2000; Swain & Miller, 2000). Currently, natural breeding is the most productive method for propagating this species (Keele and Dimeo-Ediger, 1999; Hutchins & Smith, 2001), therefore it is necessary for managers to encourage natural species-specific behavior of elephants living in captive circumstances. It is understood these behaviors will enhance both their physiological and psychological well-being and therefore the likelihood of reproductive success (Schapiro, *et. al.*, 1998; Boinski, *et al.*, 1999).

Summary

In Chapter II zoo history as well as present day zoos were explored. The formation, mission statement, and purpose of the AZA were discussed as was how zoos are governed and to whom they are responsible. Elephant husbandry in North American zoos and problems connected to elephants in captivity were considered.

CHAPTER III

AFFILIATION OF STRESS AND WELL-BEING IN CAPTIVE ANIMALS

Chapter Rationale

Chapter III investigates the nature of stress and its influence on the physiological and psychological systems of animals. Stress is defined then thoroughly examined in order to better understand the challenges of animals in captivity and the profound effect on their nature. The well-being/welfare of these animals is also discussed.

Stress Defined

The Merrian-Webster's Collegiate Dictionary (2004) defines stress as a "physical, chemical, or emotional factor that causes bodily or mental tension and may be a factor in disease causation; a state resulting from stress especially one of bodily or mental tension resulting from factors that tend to alter an existent equilibrium."

Stress occurs when a stressor (cause of stress) interrupts the process by which the body of an organism maintains a relatively constant internal environment. This process is referred to as homeostasis, and it is vital to the well-being of an individual (Broom & Johnson, 1993). When homeostasis is upset, the body responds by producing a set of behavioral and physiological reactions which are designated the "stress response." In defining stress it is good to remember that the term often refers to either the stressor or the response to stress.

Nature of Stress

Stress response is a state of excitation which is marked by neural (or mental) alertness and physical preparedness in the face of a challenge or stressor. This ubiquitous response is the same whether the stressors are tangible or perceived, since homeostasis is regulated by the hormones that mediate stress (Charmandari, *et al.*, 2005). Be it an attacking predator or an alarm call, the same chain reaction occurs. Physical and mental faculties rally towards one of two possibilities: fight with the stressor or flight from it (Broom & Johnson, 1993; Ladewig, *et al.*, 1993). Both responses involve a high level of physical and/or mental activity, which enables an organism to mobilize its resources to meet some form of trial (Nolen, 2002). This reaction is dependent on the secretion of a number of chemical messengers.

The stress response is defensive in nature and is activated primarily by the release of the catecholamine epinephrine from the adrenal gland's medulla and by the secretion of norepinephrine into target organs by the Sympathetic Nervous System (Stratakis & Chrousos, 1995; Charmandari *et al.*, 2005). It also acts to prepare the body for the possibility of being injured. The catecholamines being secreted promote more rapid clotting of blood (Charmandari *et al.*, 2005). The stress response also prepares the body for a long flight, if necessary, by releasing other stress hormones. Most notable of these is cortisol (Carlstead, 1992), which is a steroid produced in the adrenal cortex.

Contrary to common belief, the stress response is not necessarily a conditioning experience. That is, one stress episode does not "toughen up" the individual for a second or third sequential stress bout. In fact, the opposite applies. A serious stress episode seems to make one more susceptible to the effects of those that follow in rapid sequence

(Young *et al.*, 2000). Simultaneously occurring stressors are thought to have an additive effect. This is particularly true with physical stressors wherein one disease state may seriously decrease the body's defense mechanisms to other diseases. For example, starvation (a stressor) decreases the effectiveness of the immunological defense, probably because of the decreasing availability of amino acids. Therefore, a starving animal becomes more susceptible to bacterial infections. Psychologically produced stress responses are also considered to be additive. Many of the consequences to this variety of stress (whether single or multiple stressors) are dependent on the animal's perception of the episode. This type of stress accounts for most stress found in captive circumstances.

Acute and Chronic Stress Response and its Outcome

The physical reaction to stress can be an acute or immediate response such as the "fight or flight response" or a chronic response like the release of Corticotrop Releasing Factor (CRF) over a long period of time.

In an immediate "fight or flight response," the following physiological changes take place (Cannon, 1929). Initially, the neuro-endocrine systems alter heart and blood vessels to enhance blood flow to the areas of the body that are directly involved with the fight or flight reaction, sending blood to skeletal muscles while shutting off the flow to nonessential body functions (Ganong, 1997; Bauman, 2001). When homeostasis is disrupted, more energy is needed than is readily available so nonessential systems are inhibited to insure survival. Next, the catecholamine hormones epinephrine and norepinephrine are released. These hormones are responsible for vasoconstriction in some muscles and vasodilatation in others. Their combined effect is to direct the blood flow mentioned in the initial reaction. After that, blood flow increases and the force by which the blood is being shunted to vital areas causes the heart to increase both in its rate and the force of beating (cardiac output)(Pepe *et al*., 2004). The fight or flight response also requires an increased airflow into and out of lungs in order to oxygenate blood more rapidly. This is accomplished by epinephrine, which also dilates airway vessels, thus reducing airway friction and increasing the rate of breathing (Broom & Johnson, 1993; Ladewig, *et al.*, 1993). Other body parameter changes include a rise in temperature as a response to epinephrine release. Sweating is encouraged by the action of norepinephrine on sweat glands by way of the sympathetic division of the Autonomic Nervous System (ANS). There is also an increase in availability of glucose (brain food) to the body due to the affect of epinephrine on the liver and the skeletal muscles. This is to meet the increased energy demands of the body during a stressful situation. Moreover, epinephrine's effect on the brain is also associated with an increased rate of learning and memory retention (Broom & Johnson, 1993).

The primary elements of the chronic stress response and most frequent pathologic outcomes of long term contact with stress are as follows: 1. using up energy at the cost of storing energy can result in fatigue, myopathy or steroid diabetes (Ladewig, *et al.*, 1993; Hnath & Yannessa, 2002; Carpenter, 2003); 2. increased cardiovascular and cardiopulmonary tone can result in hypertension (Ladewig, *et al.*,1993; Broom & Johnson, 1993); 3. suppression of digestion can result in ulceration (Broom & Johnson, 1993); 4. suppression of growth can result in psychogenic dwarfism, or bone decalcification (Altermus *et al.*, 2001); 5. suppression of reproduction as a result of anovulation, impotency or loss of libido (Carlstead. & Shepherdson, 1994); 6. analgesia can mask symptoms of illness (Cabib, 1993); and 7. neural responses, including altered cognition and sensory thresholds, can result in accelerated neural degeneration during aging (Becker *et al.*,1992). The wear and tear of stress bouts eventually leads to the break-down of body systems and death (Altermus *et al.*, 2001).

Another aspect of stress which concerns not only captive animals but also humans is that when food is abundant, energy intake is unnaturally elevated. Animals in their natural environment may go extended periods of time without food or with minimal amounts. In a captive state, it is considered only humane to provide rations daily and in generous portions. Trained dietitians consider daily intake as the number of calories required to sustain the animal/ day, which encourages a tendency of animals to over eat in response to stress. Actually, in natural conditions the animal does not get that much food in a day and the body weight of a wild animal is not nearly that of a captive animal. As a result of raised energy intake as well as a boost in cortisol due to stress from captivity, levels of insulin are elevated (Strack *et al.*, 1995). Corticotropin-releasing factor (CRF) neurons activity is strongly influenced by calorie intake (Bell *et al.*, 2002). A combination of elevated insulin and corticosteroids results in fat being distributed around the belly of the animal. This type of obesity in humans and animals is associated with cardiovascular disease, diabetes, and stroke.

Coping Mechanisms and Stereotypical Behavior

In 1936, Hans Selye investigated how organisms cope with stressors. He found that coping consists of three stages. In stage one of the alarm reaction, the stressor is detected, in Stage 2, the animal mounts resistance to the stressor when coping occurs, and ultimately, in Stage 3 the animal becomes exhausted, the stress response shuts down, and finally stress pathology takes place (in extreme instances causing death) (Dallman, 2003). He designated this progression as the general adaptation syndrome (GAS) (Selye, 1950). Even though Selye postulated that the exhaustion phase was due to termination of the stress response, present-day research suggests that stress pathology is a result of long term-contact with CRF and related stress hormones (Sapolsky, 1992, 1994; Chrousoe, *et al.*, 2003).

The initial attempts of an organism to cope with new situations by using the collection of behavioral and physiological responses that are provided by its species and individual experience are termed arousal (Cabib, 1993). If this process is successful, either by a well-established response or a newly-learned one, the animal is benefited. However if the individual or environment discourages coping, then stress occurs (Puglisi-Allegra, *et al.*, 1990a, b). Other researchers suggest that stress occurs when an organism loses its ability to cope with a stressor at a behavioral level (Levine & Wiener, 1989). In either case when coping strategies don't work, stress becomes acute and animals often resort to stereotypic behavior.

Stereotypic or abnormal receptivity behavior (ARB) refers to mannerisms that are repeated over and over in an identical manner and do not serve an apparent function or goal (Carlstead, 1992). For a behavior to be classified as an ARB, five questions must be answered (Garner, 2005). First, is the behavior seen only in captivity? Second, if seen in the wild as well as captivity, is the behavior performed in an inappropriate circumstance? Third, does the behavior involve self-injury, affect social interactions, or have deleterious consequences on growth or reproduction? Fourth, is the behavior peculiar to a subset of individuals? Lastly, does the behavior induce signs of distress in the animal or its companion? Armed with a valid criterion for accurately identifying stereotypic behavior, caregivers can better prepare timely interventions for their charges and reduce atypical behaviors.

There are two categories of atypical conduct: 1) maladaptive behaviors, in which a normal animal is caught up in an abnormal situation and is coping as best it can, and 2) malfunctional behavior in which the animal behavior is a result of abnormal psychology, brain development, or neurochemistry exacerbated by being in captivity (Garner, 2005).

Appreciating which mechanistic category an animal fits into can be useful when establishing an effective means of creating a sense of well-being for that individual. ARBs are not the only deviant types of demanding behaviors.

Aggressive or destructive behavior (Garner, 2005) is frequently found in animals living in artificial environments. Linking stress and stereotypic behavior in captive animals has proven to be challenging due to the influence of intrinsic inconsistencies. Investigators indicate that these inconsistencies are a result of an individual animal's perception of stressors and the complex control of each distinctive neuroendocrine system (Ladewig *et al.*, 1993). However, the fact that stereotypical behavior such as cribbing, bar licking, over grooming, head bobbing, and pacing are primarily found in captive animal makes stress a likely explanation (Lawerence, & Rushen, 1993; Priest, 1991). These behaviors occur at a high rate for a long period of time and are believed to erode the animal's ability to interact with its environment.

Cooper and Nicol, (1993) offered their "coping hypothesis" as a possible clarification of stereotypical behavior. In general they suggest that stereotypic behavior is a response to unfavorable or stressful conditions (possibly captivity, drought, or illness), and that when an animal performs this type of behavior the level of stress in that experience is reduced. However there are those who suggest alternate explanations. Some see these aberrant behaviors as a result of sensory overload. Individuals exhibiting these behaviors are not able to process their environment in an organized manner, much like victims of Autism. Possible treatment for this state would be drug therapy (Pickar *et al.*, 1982). Others believe that these behaviors are a direct result of the affected individual not being able to work off excess energy, and could be eliminated by providing physical activity (Carlstead, 1992; Pedersen & Hoffman-Goetz, 2000). It is possible that they are an effect of a combination of all of these. In any case stereotypical behaviors are rarely found in animals in their natural environment.

Adaptive Features of Stress

Darwinian's theory of evolution insists that a species either adapts to the challenges of its environment or becomes extinct and organisms currently exist only because they evolved adaptations that allow them to cope with environmental demands (Shettleworth, 1998). In the "game of life," Darwin (1859) points out that the animals that live longer will leave more off-spring and will therefore have more input into their species' gene pool. Individuals that successfully cope with environmental stressors adapt better and live longer. These individuals have more opportunity to reproduce and have offspring who are better equipped to cope with stress. By passing down these positive behavioral and physiological attributes, species survival is enhanced (Bauman, 2001).

Stress response is most often an acute response in a natural environment. It is valuable to keep in mind that the consequences of stress are not always negative. Reeder & Kramer (2005) describe how the sympathetic nervous system response and the regulation and reactivity of the hypothalamic-pituitary-adrenal (HAP) axis account for how animals respond to both predictable and unpredictable environmental changes. A few examples of natural stressors are 1. group dynamics: dominance/ submission, change in group hierarchy; 2. territoriality, defense/intrude; 3. breeding rites and mating; 4. birth and nurture of young; and 5. predator encounter, mobbing/escaping. Long-term stressors may include drought/flood, extremes in temperature, natural disasters and the impact of man (Reeder & Kramer, 2005).

Differentiating stress responses and stressors as having a negative or positive influence on an individual is an area of investigation that has received a good deal of research. In 1976, Dr. Hans Selye (1976) used the term "eustress" as the benign or positive response to a stressor and "distress" as the negative or malignant response to a stressor. Eustress may be life-events such as breeding, giving birth, encountering a new experience (behavioral enrichment event) or moving to a better enclosure. Distress, a more negative stress response, could be elicited by such life-events as illness, being captured, or change of leadership or status within a group (Nolen, 202).

It is important to understand that it is possible for eustress to become distress. For example receiving too much grain can cause a horse to founder or eat so much that it gets sick. Also an individual's perception of a stressor can change and what was once a positive experience becomes a negative one. Another important fact about eustress/distress is that others may recognize as a negative a stressor that is perceived by some as positive. It is certain that stress is a motivating dynamic which seems to be essential, that its effect is not only mental but also physical, and that it is dependent on an individual's perception of a challenge.   The goal of enrichment is to reduce the distress load that captivity places on animals by making their habitat as close to their natural environment as possible, thereby eliciting natural behavior (Carlstead & Shepherdson, 1994).

Comparing a Captive Animal to its Wild Counterpart

Philosopher, Dale Jamieson suggests in his 1995 article, (Jamieson, 1995) that the lines between wild and captive animals are blurred and that the only way many wild animals will survive is for them to either be brought into zoos or their populations managed in their natural habitat. In either case the essence of "wild" has been compromised, most likely never to return. As a philosopher, he asks the question of whether this is morally permissible. Do humans have the moral right to dominate every environment and thereby destroy "the wild"? If Jamieson is correct, then it is time to compare wild animals with those in captivity.

Many times the physical act of capture results in the animal's exhibiting symptoms such as depression, metabolic acidosis, stiff muscles (possibly to the point of them being uncoordinated or even paralyzed), myoglobinuria, and in most instances death. This state is most commonly called capture myopathy (Chalmers & Barrett, 1982). Even when handlers are careful not to exhaust the animal, and to reduce heat stress, and to minimize direct contact with humans, the trauma of being captured is so distressing that animals often die. Whether an animal is being darted for a medical reason or to be sent to another zoo, capture myopathy is a possibility which is taken into account by the captors (Bartsch, *et al.*, 1997)

Human captives exhibit many of the physical and mental indicators displayed by their animal counterparts. Studies made of men taken prisoner in WWII found deficits in attention span, learning capacity, and memory retention (Fairbank, *et al*., 1991; Sutker, *et al.*, 1994). There were no comparable captive animal studies made in these areas, but there were in other areas such as sleep disorders (Guerrero, & Crocq, 1994), aggression, depression (Strentz & Auerbach, 1968), and other mental disorders (in humans the term Posttraumatic Stress Disorder (PTSD) (Sutker, & Allain, 1996)) is used. These studies produced comparable results; after the initial capture both humans and animals display sleep disorders, aggressive outbursts, and what could be considered PTSD (Constableet *et al.*, 1998; Kunzl, *et al.*, 2003; Fernandez- Mordn*, et al.*, 2004).

Studies comparing stress hormones and behavior in newly captured and those animals born in captivity have provided insight into a variety of species in an assortment of circumstances. Kunzl *et al*. (2003) compared two subspecies of domestic guinea pigs. They used *Cavia* aperea porcellus as the control population and two test populations of wild guinea pigs *Cavia* aperea. Kunzl and colleagues wanted to determine whether rearing wild mammals in captivity affects their behavior and physiological stress response. One of the wild populations consisted of wild-trapped animals and their first laboratory-reared offspring. The other population of animals was reared in captivity for 30 generations. They found that long-term breeding and rearing of wild guinea pigs in captivity does not result in significant changes in hormonal stress responses. It takes a much longer period of time and artificial selection by man to bring about characters of domestication in wild animals. As in Kunzl's research, Constable, *et al.*, (1998), and members of his group clearly established that differences exists in serum biochemistry between captive and free-ranging populations of gray wolves, <u>*Canis* lupus</u>.

Wolves in captivity exhibit biochemistry which designates high stress parameters. In contrast to the other two investigations, Borchard, *et al*, (1982) conducted a study that compared serum proteins, electrolytes, and metabolites (to determine stress levels in captivity) in wild and domestic horses and found different results. Their findings indicated that wild horses are not a separate subspecies of horse but a feral horse derived from a mixture of domestic breeds with comparable biochemistry levels (Borchard, *et al.*, 1982). Captivity does not elicit a sustained negative stress response in wild horses as compared to their domestic counterparts.

Animal Welfare or Well-being

Well-being **is** the state of being happy, healthy, and/or prosperous (Merrian-Webster's Collegiate Dictionary, (2004). Well-being/ welfare are difficult to define. Using words like "happy" involves struggling with such mental concepts as thoughts, emotions, and feelings. At best it is extremely hard to define these ideas for our own species, much less for other varieties of animals. What is enriching for one species may be deleterious to another.

Even though the term "well-being" is used frequently, its meaning is dubious and dependent on the discrimination of individual users. According to many of the scientists involved with "animal rights," agreeing on a definition of "well-being" is next to impossible (Duncan & Dawkins, 1983; Broom & Johnson, 1993). For this reason, in the early nineties an unscientific definition was accepted and the term "well-being" continued to be used, notwithstanding its ambiguous meaning. In this manuscript "welfare" and "well-being" are used interchangeably while keeping in mind the extensive scope of ideas they both encompass.

Welfare is defined as "the state of doing well especially in regard to good fortune, happiness, well-being, or prosperity" (Merrian-Webster's Collegiate Dictionary, 2004). Pertaining to animals, the word "welfare" no longer possesses the dictionary connotation, but instead holds various meanings. In some literature, people liken welfare to the lack of suffering, leaving the question of psychological (emotions and/or feelings) completely out of consideration (Duncan, *et al*., 1993). By example, Hutchins, et *al.* (1995) regarded welfare as "A state of complete mental and physical health, where the animal is in harmony with its environment."

Broom (1986), on the other hand, proposes a more scientific view and postulates that welfare is its sate of being as it tries to cope with its environment. This definition suggests a number of significant truths about Broom's concept of animal welfare. First, welfare is a characteristic of an animal, not something given to it. Second, welfare can vary along a scale between very poor and very good. Third, welfare can be measured in a scientific way that is independent of moral considerations. Fourth, an animal's welfare is poor when it is having difficulty coping or is failing to cope with its circumstance. Fifth, animals may use a variety of methods when trying to cope, and there are various consequences of failure to cope (Broom & Johnson, 1993). Sixth, pain and suffering are important aspects of poor welfare. Finally, welfare is affected by what freedoms are given to individuals and by the needs of individuals, but it is not necessary to refer to these concepts when specifying welfare. These concepts have been the foundation for many enrichment efforts in many institutions.

It is a complex situation when the meanings of these terms are so varied, but if animal welfare is going to be a scientific endeavor, there must be a common vocabulary. Systematic inquiry is the only approach to insure significant validity in determining how successfully an animal is coping with its environment.

Coping: A Gateway to Well-being

There will always be challenges for an animal in any environment. Its welfare is depends on how successfully it copes with those influences. Coping indicates the animal's ability to diminish the negative impact of stressful events. If it is able to successfully deal with such an event, unpleasant feelings are decreased and the animal's welfare is positively affected.

Coping strategies include cognitive and behavioral responses to stressors. Examples of a cognitive response could be the ability to interpret, or remember previous events (whether negative or positive). Behavioral responses may include escaping, problem solving, seeking social support, or scaring away threat. An animal's ability to adapt to threats, challenges, and adversity is the primary determinant of the level of well-being. In other words, well-being comes from successfully coping with problems not from a problem-free life where no coping skills are needed. This must be kept in mind in development of management decisions because challenges in an environment with some unpleasant events are more supportive of well-being than a benign and sterile (although physically safe and healthy) environment.

Because behavior is one of the main tools utilized for coping, our observations of animal behavior become critically important in evaluating well-being. In the management of captive animals, we must be able to measure their level of well-being as an animal. Managers must be able to evaluate an individual's state of well-being with assurance that they can accurately say this animal is or is not in a state of well-being. This ability insures that the success of enrichment techniques can be determined.

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Assessments of Well-being

When considering well-being (welfare), one must keep in mind the two kinds of stress, eustress and distress. Not all stress is negative. Stressful encounters such as exploring new enrichment elements of their enclosure (Mench, 1998) or mating are usually regarded as beneficial and actually contribute to the animals' physiological and psychological welfare. Chronic stress, where animals are repeatedly exposed to distress (negative stressors) and are not able to respond appropriately, can result in physiological and psychological damage. In order to evaluate well-being, a protocol must be in place at every facility.

When considering quantifying well-being, it is essential to keep in mind that it is a matter of feelings that have roots in a conscious mind. It is not possible for an animal to experience well-being or distress if it is not capable of experiencing pleasure or pain, Therefore, well-being implies that the individual is experiencing positive feelings or emotions just as distress implies that it is experiencing negative ones. Basically the measures of well-being that will be collected require information known only to the animal concerning its perception of its circumstance. For this reason it is of primary importance that each procedure be specifically fashioned to the animal being assessed. For example a researcher wanted to determine if elephants are self aware. This attribute is a characteristic of advanced functioning animals (Povinelli, 1989). Traditionally, a mirror is placed in front of the animal and its response observed. If it appears to recognize its image in the mirror then it is self aware. This approach worked well with primates but was not an appropriate design for an elephant. Consider the elephant's anatomy: its eyes are small and placed high on either side of its head. For an elephant to observe an object or event effectively, it must turn its head to the side and tilt it over, essentially aiming its eye at the point of interest. Consequently sight is not the elephant's primary sense. Instead, the sense of smell and hearing act as their primary means of perceiving their environment. Armed with this understanding perhaps a better approach would have been to utilize those attributes. Sometimes an innovation in the design of a trial is required so that accuracy is not lost.

The status of the physiological and psychological condition of an animal can be effectively measured as indicated by Broom & Johnson's list (1993). This is accomplished by means of a physical health assessment of the animals, physiological measures of stress, and observation and documented activities of animals to quantify typical (eustress) and atypical (distress) behavior (Dath, & Minnemann, 1992). This is fundamentally a scientific process. We use objective information to formulate hypotheses about what kinds of behavior indicate well-being and the changes that we can make to achieve these behaviors. We then test the hypotheses by making the changes and observing the results. For example, Veasey *et al.*, (1996) suggested that comparing the behavior of animals housed with conspecific may offer an effective welfare indicator (Veasey, *et al.*, 1996). This hypothesis was tested and met with limited success.

Even if our enrichment activities are not part of a formal scientific study involving objective measurement, as most are not, we are still following this process, even if only in our minds. It is this philosophical underpinning that gives enrichment the power to grow beyond the bounds of tradition and habit and continue to evolve in the light of observation and experience.

Summary

Chapter III has investigated the nature of stress, its mechanisms, and its effect on animals. An animal's reaction to stress and how it impacts its well-being was examined in detail, as were possible solutions to negative consequences of living in stressful conditions.

CHAPTER IV

EFFECT OF ENRICHMENT IN NORTH AMERICA

Chapter Rationale

The purpose of Chapter IV is to explain the use of enrichment practices in institutions housing captive animals with regard to enhancing their well-being. Enrichment is defined, a brief history given, and its utility explored.

Enrichment Defined

The Merriam-Webster's Collegiate Dictionary defines enrichment as "to be made rich or richer by the addition or increase of some desirable quality, attribute, or ingredient" (Mish, 2003).

Environmental and Behavioral Enrichment Defined

Environmental enrichment describes how that the environment of a captive animal can be altered and have a positive effect on its well being. The resulting changes in the animal's behavior that may arise or increase as an effect of environmental enrichment are considered to be behavioural enrichment (Shepherdson, 1994). Simply put environmental enrichment is the alteration of an animal's environment in order to enhance its well-being (Peterson, 1994). Environmental enrichment enhances the surroundings of captive animals by means of developing better methods of nurture according to the specific animal's natural life style and behavioral ecology. Enrichment is a dynamic process that has evolved over time as its significance in captive settings has become apparent.

Purpose and Implementation of Enrichment

Reduction in stress can be realized by creating interesting environments, which encourage natural behavior (Forthman & Ogden, 1992). Such challenging conditions provide animals the opportunity to solve problems, to make choices (Savage *et. al.*, 1994) and to obtain a sense of control of their environment, thereby easing their stress (Forthman & Ogden, 1992). Possible alterations of exhibits could include increasing the size of habitats (Sherwin, 1988; Wenz, 1996), better use of existing spaces, introducing innovative items into their environment (Bayne, *et. al.*, 1993; Powell, 1997), positing non toxic vegetation in and around the enclosures, and installing a watering or mud hole (pool). Many zoos now have a staff of botanists who manage the care, selection, and placement of appropriate plants for each exhibit. When adding visual barriers are added to the environment, animals can choose to withdraw from visitors and or be conspecific (Hemphill & McGrew, 1998). Another aspect of environmental enrichment is placing social animals in a grouping of their own species or by assembling an assortment of mixed species that would ordinarily be found together in a natural setting. This design can supply diversion or even encourage interaction between the species.

An additional area that lends itself to enrichment is in the everyday care of animals by their keepers (Wenz, 1996). Zookeepers do not only tend to the physical needs of an animal but also acquire a depth of understanding concerning their behavioral needs. Food delivery can provide an opportunity to enhance the daily experience of animals (Shepherdson, *et. al.*, 1993). Some examples are the presentation of food at various times of day or after a random or triggered behavior or event (Hemphill & McGrew, 1998), appealing to the sense of smell by putting spices or herbs in food, encouraging exploration and natural foraging by hiding food throughout the exhibit (Rapaport, 1998; Wiedenmayer, 1998) or giving animals puzzle feeders (Field & Thomas, 2000; Novak, *et. al.*, 1998) to enhance problem-solving skills and occupy time and feeding food items whole instead of chopped up or in pellet form. Other ideas that keepers employ to provoke activity are dispersing animal scents around the enclosure or having simulated prey items as part of a predator species habitat. If possible it is important for these events to be random and/or spontaneous to elicit natural responses. In her 1999 article, Carlstead targeted the need for control, exploration, and play to counter the effects of the stresses of captivity (Swaisgood, *et al.*, 2003).

Enrichment Timeline

<u>1911</u>

A paper was presented to the zoological society stating that if the zoo put polar bears on exhibit, they would have to provide toys and other items for them due to their playful nature. Sadly nothing was done for the bears until the 1980's (Young, 1998).

<u>1896</u>

William T., Gardner recommended enrichment activities for primates to enhance their well-being (Maples & Finlay, 1989). His suggestions included adding tires, rope swings, and climbing devices to the environment as well as providing fresh fruit to their diets.

1907

Carl Hagenbeck's first undertakings were as merchant and trainer of wild animals. He was highly successful at both. However his love of landscape paintings and the animals he worked with inspired him to create an innovative, more humane, approach to displaying captive animals. With the help of his architect, Jonathan Eggenschwiler, they designed and constructed "naturalistic landscapes" to provide captive animals a sense of ease in their environment, thus improving well-being (Young, 1998). For this reason Hagenbeck is considered to be one of the founders of environmental enrichment.

Here are a few other interesting details about Carl Hagenbeck. He was the creator of what was called the "human zoo" where he would present humans along side of animals in static displays. In 1907 Hagenbeck founded the Tierpark Hagenbeck zoo in Hamberg-Stellington, Germany, which is Germany's most successful private zoo (Wikipedia, online). Lastly, he was responsible for importing to England their celebrated elephants Salt and Sauce.

1925

The first environmental devices were advocated by primatologist Robert Yerkes, with the purpose of stressing the impact of physical and social environments on the well-being of animals in captive settings (Mellen & MacPhee, 2001). Yerkes was raised on a farm, which accounted for his interest in animal behavior and his pursuing a career in comparative psychology. His area of interest was in the study of human and primate intelligence and the social behavior of gorillas and chimpanzees. His first book, *The Dancing Mouse* was published in 1907.

Yerkes is considered to be a cofounder of environmental enrichment along with Carl Hagenbeck. His lifetime goal is summed up in his own words, "The greatest possibility for improvement in our provision for captive primates lies in the invention and installations of apparatus which can be used for play or work (Yerkes, 1925)." He invented devices such as those that stimulated the animal's sense of hearing by using played back vocalizations and those that promoted natural wild primate locomotion. He also utilized apparatus that could be filled with natural foods which were stimulating to the sense of smell. These devices were designed in a way that the animal had to solve a problem before it could get to the item. Yerkes believed that these activities enriched the animals mentally and physically giving them autonomous decision-making control in their captive environment and thereby a sense of well-being.

<u>1930s & 1940s</u>

There were no notable accomplishments during this period of time. World War II and the "Great Depression" may have had much to do with the lack of progress in enrichment.

<u>1950s</u>

In his 1955 article Hediger, (1955) first used the terms "environmental enrichment" and "behavioral enrichment," indicating a growing awareness of a need for study and utilization of an animal's natural history to provide animals a more stress-free ambiance.

<u>1960s</u>

Even before "enrichment" was emphasized, many of those who cared for captive animals would daily make an effort to improve the well-being of the animals they cared for. For example, keeper Desmond Morris used the natural history of seals in his care when he created a device that released fish into their pools, simulating natural feeding behavior (Maple & Finlay, 1989). Those responsible for creating enclosures took notice and began using the natural history of the animals as a source of inspiration for their design.

<u>1973</u>

Charles Watson (a student at the University of Edinburgh) conducted the first environmental enrichment study. It was carried out in a zoo milieu (Young, 2003). Unfortunately, Mr. Wilson's only notable accomplishment was the distinction of being the first to do his research project in a zoo.

<u>1980s</u>

Shepherdson, in 1989, suggested criteria for what an enrichment project has to do to be effective. He first proposed that there must be some evidence that behavior has changed for the better, and that it should be evaluated in quantitative behavioral measurements. Second, he added that enrichment must be practical. If it involves excessive time, money, and/or effort to implement, it will be unlikely to last for long. Third, an enrichment technique must be effective over a reasonable length of time. Often enrichment techniques are successful at first because they are novel to the animals but once they cease to be novel they may become less effective. Finally he advised that the project must be compatible with the facility's goals.

2000s

There is a realization that the first criteria recommended by Shepherdson in 1989 to evaluate the effectiveness of enrichment projects required a more rigorous scientific approach. A stronger emphasis on sample size (inter zoo studies), experimental design, statistical analysis, and better description of environmental design, was unquestionably required to support innovative, fruitful enrichment efforts (Swaisgood & Shepherdson, 2005). Species-specific research is necessary to provide an extensive knowledge base for every species. Such a knowledge bank can provide management and staff a source of information that will enable them to produce effective, productive, enrichment experiences for their charges and insure continued advancement in the effectiveness of enrichment efforts. It is essential that research in both approaches to enrichment be systematically explored.

Approaches to Environmental Enrichment

Two men are considered the founding fathers of environmental enrichment. Each brought his own individual perspective to the discipline. In 1907 Carl Hagenbeck drew on his love of landscape paintings for his vision of animal presentation in captive situations. This naturalistic approach "relies on creating the wild environment in captivity to provide stimulation for captive animals" (Young, 2003). The naturalistic approach proved to be a "win- win" situation for the public and the inhabitants of a facility. As visitors observed animals in their natural setting, they were educated in natural history as well as the behavioral ecology of animals they viewed. Animals benefited by occupying enclosures that encouraged innate, species-specific behavior in a realistic habitat (Tudge, 1991).

Robert Yerkes is responsible for the second approach. He advocated the use of devices which could be installed in primate environments which would encourage them play and work. Thus behavioral engineering relies on introducing apparatus and machines that animals can manipulate to obtain some type of reward, usually food, (Young, 2003). He proposed that behavioral engineering replaced the artificial approach and restored the natural occurrence between the production of appetitive behavior (foraging) and the presentation of consummator behavior (feeding), (Young, 2003). This approach was not readily accepted by the zoo community, however in the 70's Yerkes method began to come into its own.

Many times professionals in the field have a tendency to exhibit an either/or attitude about whether they follow Hagenbeck's or Yerkes' approach. In doing so, they lose the opportunity to draw the best possible approach for the specific animal they are working with. Instead of using an excusatory decision-making process, captive animals may profit more when the criteria are whatever works best for that animal under the specific situation. The success of an enrichment project is dependent on the energy and thought that the caregivers put into it and their dedication to following it through once the project is implemented. For a long time, behavioral enrichment was usually carried out by keepers when they had extra time to devote to it, so there was a disparity in the amount of time for enrichment among animals in a facility. Efforts were concentrated mainly on high profile animals like primates while other, less visible animals were passed over. Even though administrators of institutions encouraged enrichment projects, there was no comprehensive design for every area.

Enrichment consists of activities such as delivering food by hiding it in the animal's habitat, which encourages exploration and increased activity, as well as making modifications to enclosures that stimulate natural behavior (Stoinski, *et al.*, 2000). Training programs are a valuable tool in an enrichment program. Operant conditioning is utilized in order to encourage animals to voluntarily participate in routine procedures, thereby eliminating the need for physical or chemical restraints. Forming social groupings which resemble those in their natural condition is also a valuable practice. Animals within a social group are often interacting in various ways such as mating rituals, playing, grooming, or other social behavior. Finally, sensory stimulation appeals to the primal senses (hearing, sight, smell, touch, and taste) of the animal to mimic life in the wild. This can be accomplished by playing vocalizations, using pray chase apparatus, putting pheromones in the enclosure, and presenting differing textures of food items and/or materials in their enclosure.

American Association of Zoological Parks and Aquariums (AZA) Addresses Enrichment Concerns

By the early 1990's, environmental enrichment had started to have an impact on how institutions were caring for their animals. The American Association of Zoological Parks and Aquariums (AZA) responded to the need for current enrichment information by distributing a newsletter called *Shape of Enrichment.* This publication updated and provided a forum for animal care specialists involved in the implementation and science of enrichment. About the same time, the American Association of Zoo Keepers (AAZK) also created an enrichment committee and began to issue articles about enrichment (Shepherdson, 1989; Hutchins, 2001). They also published several editions of the comprehensive *AAZK Enrichment Handbook.*

The first International Environmental Enrichment conference was held by the Oregon Zoo in 1993. Its purpose was to further consciousness concerning the significance of a rigorous scientific foundation for enrichment efforts. These biennial conferences are held worldwide and continue to be a focal point for ground-breaking ideas and inventive application of enrichment techniques.

An additional vital method for relating insight and interest has been the AZA enrichment online "listserve." A web-based catalog system is currently under construction by the Fort Worth Zoo. It will expand the possibility of maintaining improved accessibility and complexity of information.

The formation of the AZA Behavior Advisory Group (BAG) in 1996 provided a formal forum of experts in behavior and husbandry to support the science and application of enrichment in AZA institutions (Leach, 1995). The mutually dependent topics of enrichment and welfare continue to be a primary focus of the BAG, and major multi-institutional research (Markowitz, 1982) by David Shepherdson, Conservation Program Scientist, and Ore.

Enrichment Put into Practice

Reduction in stress can be realized by creating interesting environments, which encourage natural behavior (Forthman & Ogden, 1992). Such challenging conditions provide animals the opportunity to solve problems, to make choices (Savage *et. al.*, 1994) and to obtain a sense of control over their environment, thereby easing their stress (Forthman & Ogden, 1992). Possible alterations of exhibits could be increasing size of habitats (Sherwin, 1988; Green, 1989), better use of existing spaces, introducing innovative items into their environment (Powell, 1997; Bayne, *et. al*., 1993), positing non toxic vegetation in and around the enclosures and installing a watering or mud hole (pool). Many zoos now have a staff of botanists who manage care, selection and placement of the appropriate plants for each exhibit. By adding visual barriers to the environment animals can chose to withdraw from visitors and or nonspecific (Hemphill & McGrew, 1998). Another aspect of environmental enrichment is placing social animals in a grouping of their own species or by assembling an assortment of mixed species that would ordinarily be found together in a natural setting. This design can supply diversion or even encourage interaction between the species.

An additional area that lends itself to enrichment is in the everyday care of animals by their keepers. Zookeepers do not only tend to physical needs of an animal but also acquire a depth of understanding concerning their behavioral needs also. Food delivery can provide an opportunity to enhance the daily experience of animals (Shepherdson, *et. al.*, 1993; Haight, 1994). Some examples are: 1) presentation of food at various times of day or after a random or triggered behavior or event (Haight, 1993; Hemphill & McGrew, 1998) 2) placing spices or herbs in food 3) hiding food throughout the exhibit (Rapaport, 1998; Wiedenmayer, 1998) or giving animals puzzle feeders (Field & Thomas, 2000; Novak, *et. al.*, 1998) to enhance problem-solving skills and occupy time and 4) feeding food items whole instead of chopped up or in pellet form. Other ideas that keepers employ to provoke activity are dispersing animal scents around enclosure or having simulated prey items as part of a predator species habitat. If possible it is important for these events to be random and/or spontaneous to illicit natural responses. In her 1999 article Carlstead targeted need for control, exploration and play to counter the effects of stresses of captivity (Swaisgood, *et al.*, 2003).

Enrichment requires a vigorous exchange between creative enclosure improvements and innovative husbandry techniques, with the objective of providing captive animals more control over their lives. Control is achieved by offering captive animals' diverse behavioral options to choose from thereby requiring them to exhibit species-specific behavior and ability. This practice gives animals back control over their environment and is a prime factor in their welfare or sense of well-being.

Summary

Chapter III related the definition of enrichment, its purposes, and practice as well as why it is so necessary. The history of enrichment is outlined to give historical perspective. Benefits animals receive and how well-being is measured were addressed.

CHAPTER V

ASSESSMENT OF ANIMAL PLAY AND POTENTIAL UTILIZATION OF PLAYAS BEHAVIORAL ENRICHMENT FOR CAPTIVE ASIAN ELEPHANTS (ELEPHAS MAXIMUS) IN NORTH AMERICAN ZOOS

Chapter Rationale

Chapter V explores the subject of play in mammals. The nature of play is clarified and the three types are discussed. Application of play in enrichment techniques is examined as well as toy use.

Play Defined

There are 50 dictionary definitions of the word "play" so it is not surprising that researchers in this area have a problem agreeing on a definition of the term. In 1975 E. O. Wilson affirmed play as vague, elusive, divisive and even outmoded as a behavioral concept (Wilson, 1975). Since then, increased interest in this area of animal behavior has led to a sizable boost in research and consequently understanding. Unfortunately, even with this progress, the definition of play remains vague, but not quite as elusive, and controversial.

Leading authority Bekoff (2001) proposed a functional characterization of play. Play is all motor activity performed post nattily that appears to be purposeless, in which motor patterns from other contexts may often be used in modified forms and altered temporal sequencing. If the activity is directed toward another living being it is called social play, (Bekoff & Byers, 1981). Another influential researcher Robert Fagen (1977) defined play as displays of behavior which accentuates abilities involved in interacting with the physical and social milieus. He suggests that these encounters take place under circumstances in which the purpose of the demonstrated ability could not ever be accomplished, (Fagen, 1977). His definition implies rules which must be adhered to implying a cognitive aspect to play. Each of the meanings is accepted and utilized by those studying play. For our purposes I will offer this definition Play is considered to be spontaneous activity in which an animal engages, for the sake of the activity itself, and it is not goal oriented. Before continuing I would like to discuss a behavior that is often confused with play.

Exploratory behavior is often thought to be play (Hutt, 1970). Berlyne describes the nature of exploration as involving all processes which affect the nature of stimulus getting to the sense organs (Berlyne, 1960); Hutt, 1970). He relates its function as afford access to environmental information that was not previously available, (Berlyne, 1960). Animals explore even when their basic needs are not met. As animals explore, they gather information. This activity is an important motivation in animals and provides a strong case for animals to live in varied, complex sensory surroundings. Animals explore voluntarily and actively seek out those experiences. They thrive on the interactive aspects of exploration. Exploration may be a component of play but it is a distinct behavior with quite discrete attributes. Much exploration is developed in an animal to access unknown environmental input, but play also has developmental functions.

Jean Piaget (1952) maintains that play is an essential element of development. He emphasized that it involves sequences of motor actions performed on symbolically used objects and that play and imitation are fundamental for formation of symbolic aptitude. Dreaming in the form of rapid eye movement during sleep is found only in mammals. Dreams are thought to be highly symbolic in nature and to indicate an inner world (Piaget, 1962). Piaget considers play a necessary component in the development of learned lifelong behavior.

Learning: A Component of Play

Whether the origin of behavior is innate, environmental, or a blending of both has been debated for many years. When watching young animals play, one becomes aware that their movements have an inherent quality as they mimic patterned adult behaviors. It is also apparent that they do not perform these movements perfectly the first time they attempt them. This supports the genesis of behavior's having both an innate and learned element. As immature animals play, their skills are refined and they learn appropriate behavior.

Learning is a somewhat long-term change (although able to be altered or eliminated, out of necessity) in an animal's possible behavior which is a result of experience. Learning has occurred when conditions in the environment generate an elemental alteration in the organism so that there is a long lasting change in the ability of the organism to respond, (Hill, 1977). The organism learns to make new adjustments or modify old behavior according to its experiences in the environment. This may be an evolutionary mechanism that allows animals to adapt to change and gives them the ability to cope in adverse conditions. This definition implies that learning can't be observed or documented as it occurs, that it is a result of experience, and that in most cases the experience is with a specific event (formation of appropriate species-specific behaviors).

Social learning refers to learning that is influenced by observation of, or interaction with, other animals, which are usually of the same species (Box, 1984). This form of play occurs mostly in species with complex social systems and is a way of building up a repertoire of behaviors that can be used on later occasions. Especially in the young, aspects of behavior that are usually incorporated in functional patterns of daily activities such as hunting, mating, and foraging for food are done spontaneously, for their own sake, and in a manner that appears to be self rewarding for the animal (Fagen, 1981). Simply put, play is performed for the joy or fun of it. There are three distinct categories of play: object, locomotor, and social.

Object Play

As the name implies, object play is the use of inanimate objects and the manipulating of such objects. This form of play has been observed in many species in the wild and in captivity. An optimal opportunity for observation has been in captivity, where toys are given to animals in order to introduce a stimulating object into an otherwise monotonous environment. Likewise most research is conducted in a captive setting because of the opportunity for the investigator to have necessary control required for a valid study. It is important to remember that interaction with an object is not always play, it can be exploration. The focus of the activity distinguishes play from exploration.

When an animal is engaging the object in a playful way, it is interested in what it can do with the item, but if it is exploring, it is concentrating on examining what the object is.

Object play in the young is associated with some aspect of rehearsing, a behavior that will benefit the animal in hunting, killing, or even identifying prey (Fegen, 1981). This clearly ties practiced-based behaviors to learning. Juvenile play behaviors mimic adult behavior in context and circumstances; this suggests that their partially formed play version may be practice for adult performance of the same behavior patterns. Adult animals model appropriate responses to specific situations and the young learn proper, specific behavior (Hall, 1998). Play may be associated mainly with the young because they have time free of other duties, such as food gathering.

This type of behavior is practiced by adults, though not as frequently as in young animals. Adult play also is different in its motivation and function. Most observations of adult play come from captive or domestic situations. All types of adult play behavior is associated with high-arousal behavior and rarely incorporates behavior patterns from maintenance or everyday activities. Play has many facets that will become evident as we proceed to other types of play.

Locomotor Play

Locomotor play is a" term used for typically solitary activity in which a young animal performs intense or sustained locomotor movements (leaping, running, prancing), often without any apparent immediate reason or stimulus" (Burghardt, 2005). It is divided into two categories, prey chasing and solitary locomotor-rotational play (Power, 2000).

Whether prey chasing should be included in locomotor or social play depends on whom you are following. For the purpose of this paper, prey chasing is discussed in social play.

The most obvious function of locomotor play is to provide general exercise and training for specific motor skills needed later in life (Byers, 1998). Exercise keeps an animal fit and therefore healthier. Physical fitness can attract a mate and enable a predator to catch prey or prevent prey from being caught. Many predators select an animal that is not as fit as the others to be their prey item. The young are building muscle and gaining coordination as they get used to their undeveloped bodies and this form of play is vital becoming a vigorous adult. Adults do derive benefit from locomotor play but not nearly as much as juveniles.

Any one who has seriously played in a sport knows that hours and hours of practice are essential to perform at the highest level. The muscles sequences involved in those movements which are required to excel are repeated over and over so that they will respond with out a thought from the athlete. So it is with a young animal play practicing to survive. This is called “muscle memory” and repetition or practice is how muscles can be prepared to respond at a hint or danger preparing the young to a successful adult.

Another function of locomotor play is cerebellar synaptogenesis that is the creation and distribution of synapses in the cerebellum. The cerebellum is involved in coordination, smooth movement, postural changes, eye-extremity coordination, and other aspects of mammal movement (Byers, 1998). Most synapses are formed early in life and the number formed is a function of experience (Brown, *et al.,* 1991). Play is timed to occur during the sensitive period of terminal cerebral development to modify synapse formation and/or elimination (Byers, 1998). Iwaniuk, and colleagues (2001) suggests that big brained mammals play more than their small brained counterparts. Perhaps this may be a factor in cerebellar synaptogenesis needed for coordination in larger animals. Social play is an extension of this type of play.

Social Play

Often social play is found in more highly evolved organisms such as mammals and birds (Siviy, 1998) and is used as a sound behavioral foundation for other necessary behaviors or life skills. When animals play they typically perform behavioral patterns that are used in other situations in their lives such as mating or predation (Siviy, 1998). They are simulations, which offer an opportunity for individuals to try out behaviors in a safe setting. Examples of such behaviors are: group feeding, infant care, mothering, bonding, mating rituals, hunting, predator avoidance, and what food can safely be eaten.

Usually social play is a co-operative exchange of behavior but occasionally animals play alone. When young animals play, they make an agreement monitored by a constant series of exchanged signals (Bekoff, & Colin, 1997). These play signals, which include pawing, a high amplitude running gate, short barks and a “play bow,” are unique to play and very obvious across species line (Byers, 1998; Rooney, et al., 2001). In most species in which play has been observed, specific actions have evolved that are used to initiate or maintain play (Byers, 1998; Rooney, et al., 2001). The fact that these signals only occur during play minimizes the risk of mistaken aggression (Burghardt, 1984). Mature animals rarely play; however, sometime they will join in with younger animals as they play (Hall, 1998).

Social play contains a great deal of aggression like chasing, biting, butting and wrestling (Pellis & Pellis, 1998). This type of play is most noticeable when animals are trying to establish their dominance or position in the peer group. Play can look like a fine-tuned version of aggression however; animal play is not true aggression. It is joyous, not serious and is modified so no one is hurt. In his book *The Descent of Man and Selection in Relation to Sex* Charles Darwin stated, "Happiness is never better exhibited than by young animals, such as puppies, kittens, lambs when playing together like our own children" (Darwin, 1856). Play usually involves role changes, and teaches the rules of social interaction. Other reasons for play are to create and cement social bonds between individuals, sharpen senses, use excess energy and occupy spare time

Cost of Play

Play behavior decreases or disappears entirely under conditions of stress associated with food shortage or drought indicating that play as well as exploration may be luxuries that are eliminated during stressful conditions (Lee, 1984). In many natural and domestic conditions inquisitive exploration and play are rarely experienced luxuries. In the wild energy conservation is a matter of life and death so as soon as survival is threatened play becomes a luxury animal cannot afford (Barrett *et al.*, 1992). For captive situations unsuitable housing arrangements (the physical surroundings) often lack the necessary stimulation to evoke play (Lawerence,& Rushen 19893). This is not to say that play is a luxury in terms of animal welfare. Play is a fundamental principle of behavioural organization and may well be central to the animal's ability to experience a state of well-being.

Prologue to Research Inquiry

Wild Asian elephants live in a complex social scheme. Highly social females reside in herds governed by a hierarchical system (Gadgil & Nair, 1984; Garai, 1992; Schulte, 2000). These herds consist of a matriarch, her sisters, their offspring, and other females with whom she was raised (Rasmussen and Schulte, 1998; Hutchins & Smith, 2001). Herd members form strong lifelong bonds (Garai, 1992). Male elephants have a very different social structure. Once young males reach sexual maturity, older females expel them from the herd, theoretically to prevent inbreeding (Eisenberg *et al.*, 1971; Rasmussen *et al.*, 1993). The juvenile males often form bachelor herds that can last throughout their teens and early twenties (Eisenberg *et al.*, 1971; Schulte, 2000; Keele, 2001). Adult males live out their lives alone (Eisenberg *et al.*, 1971).

For thousands of years Asian elephants evolved responses to genetically programmed stimuli, passing these innate behaviors from one generation to another. They lived contentedly from day to day secure within these boundaries. When their way of life was interrupted and they were brought into captivity, the inborn facets of their nature become a source of stress. In place of ancient elephant protocols, keepers determine their daily interactions. Management decisions based on practical concerns have replaced instinct.

Even in the best situations, the artificial social constructs of captivity alters natural elephant behavior. Unfortunately, reproduction is an area in which stress plays a particularly negative role. Asian elephants are a powerful and intelligent species that require environmental enrichment in captive situations to prevent boredom and subsequent aberrant or stereotypical behavior. We propose that by introducing play as a form of behavioral enrichment will decrease their stress levels and increase their sense will be decreased; their sense of well-being will increase and thereby enhance their quality of life and reproductive success. It is to this purpose that this study is dedicated.

METHODS

Chapter Rationale

Chapter VI describes the methods used for this study. Elephants spend sixty to seventy percent of their time eating. They drink two hundred to two hundred and fifty-five liters of water every day, fifty to sixty liters at a time, three to four times per day. Their trunk will hold six to ten liters at a time. They defecate fifteen to twenty times each day, and urinate ten to fifteen times per day. An Asian elephant can walk at four kilometers per hour and can run for short distances at thirty to forty kilometers per hour (Shoshani, 1992). This description makes clear the enormous commitment a zoo undertakes when caring for a herd of elephants.

Study Subject, Asian Elephant (*Elephas maximus*)

There were 10 captive Asian elephants (*Elephas maximus*) subjects: one male infant (0-1), two females and one male young adult (20-30), one adolescent (13-20) female, two females and one male middle adult (31-60), and two juveniles (1-12). While six of the elephants were wild caught at a very young age and reared at a number of facilities throughout the United States before coming to Dickerson Park Zoo (DPZ), four were born in captivity.

Research papers traditionally do not use animals' names (if they have names) in an effort to appear more objective and therefore more professional. Adopting an impersonal persona contradicts our undertaking. If these animals are to be saved, they need to be individualized. Some wise person once said that if 200,000 people die in a mass event it is a news story but if one dies, it is a tragedy. When we lose an elephant, we lose a unique individual, gone from us for good. For photographs of the subjects see supplemental file, (Figures 28, 29, 30, 31, & 32).

Animals' Housing

The elephants used in this study were housed at the DPZ in Springfield, Missouri. All were allowed variable amounts of access to outdoors when ambient temperatures were suitable (>0º). Brief sessions of outdoor access were allowed in temperatures < 0º. Each adult animal was afforded a minimum of 37.16 m^2 of space as per AZA standards.

Diet

The elephants were watered twice a day and fed herbivore pellets, vitamin E supplement, and brome or orchard grass hay ad labium. They were allowed indoor/outdoor access when temperatures were above 0º C during the day (below this temperature, they were kept inside). They were confined indoors during the night when temperatures fell below 10º C (otherwise they were allowed indoor/outdoor access at night).

Behavioral Data

Volunteers Nicole Conover and Matt Paige, under the direction of Melissa Carden, PhD, elephant keeper and primary observer, met on several occasions for practice data collection to insure consistent recording of behaviors. The majority of observation periods were conducted by Dr. Carden and Nicole Conover.

Behavioral data (see supplemental file, Figure 33) were collected in the captive environment utilizing an ethogram (Abramson, & Carden, 1998) (see supplemental file, Figure 34). This ethogram was based on information obtained in the literature concerning elephant behavior and observations of behavior by the elephant staff at DPZ. The ethogram was divided into four major behavioral categories (play, responses, vocalizations, and eating/nursing behavior). An enrichment item was placed in the animal's enclosure for a one-hour study period. Observations of behaviors were recorded at one minute intervals for all animals in the enclosure that were within three feet of the enrichment item. Animals farther than three feet from of the item were not considered interactive with it. Additionally, demographic data were recorded for each animal per study period (see supplemental file, Figure 35). The reproductive status of the animals was also recorded to determine its effect on play behavior. Males were scored for their musth status. They are considered in musth if they exhibit any combination of draining from the temporal gland, dribbling urine, and/or being highly aggressive. Females were assessed for their reproductive status utilizing serum progesterone analysis. They were scored as estrus, luteal phase, follicular phase, anestrous, or pregnant. Conditions in the environment were also recorded since they can generate an elemental alteration in the organism so that there is a long lasting change in the ability of the organism to respond.

Description of Enrichment Items

Enrichment items were designed in keeping with the thought that play is a spontaneous activity in which an animal engages, for the sake of the activity itself; it is not goal oriented. The only reward was the satisfaction the elephant received for playing with the object. The only exception was in the case of browse, which was eaten.

Because elephants are so powerful and intelligent, a particular emphasis and effort was put into the safety features (in materials used and construction) of each toy. Another factor in toy design was to promote the natural behaviors and abilities of the animals. For a toy to be useful, it must appeal to the animals' nature (see supplemental file, Figures 36, 37, 38, & 39).

Blood Collection and Analysis

A weekly blood sample was collected from the ear or leg vein of unanaesthetized female elephants (following American Zoological Association guidelines). Blood was kept at room temperature to clot and then centrifuged for 15 minutes at 1500-x g. The separated serum was stored at –20˚ C. The concentration of progesterone in the serum from female elephants was measured via radioimmunoassay (RIA) utilizing a commercial kit (Diagnostic Products Corporation, Los Angeles, CA). An established assay protocol for concentrations of serum progesterone in Asian elephants was utilized (Carden *et al.*, 1998).

Statistical Analysis

After consulting with Dr. Warde in the Oklahoma State University Statistic Department, it was decided that descriptive statistics would be applied to these data. This decision was based on several characteristics of the study. There was a small sample size of 10 subjects. The subjects were not independent of each other because they interacted while playing and some of them were related. The number of trials on individual elephants was extremely large, but because it was on the same animal it represented a repeated measure design, which meant they were not independent either. Inferential statistics assumes that you are drawing a random sample from a population.

The target population could be all Asian elephants in the world, or all Asian elephants in captivity, or even all Asian elephants in captivity in North America. In any case the 10 elephants at Dickerson Park Zoo were not considered to be a random sample population of Asian elephants. They are considered a biased sub-sample of captive elephants in one zoo. The only way to employ inferential statistic to this study would be to ignore these important tenets of statistics.

In this applied study, the goal was for other elephant management professionals to be able generalize these results and relate them to their particular situation. This study offers information that they may be able to apply to their own programs.

Calculations

Formula for Most Categories

Percentages used in this study were derived by adding the minutes of time spent in the activity and the sum was divided by the total time observed (min); the product was then multiplied by 100 to produce a percentage for the following categories:

- Age vs. Time Playing
- Inside vs. Outside Time Playing
- Gender vs. Time Playing
- Vocalization vs. Time Playing
- Submissive vs. Aggressive
- Play behaviors

- Time Spent with Enrichment Item
- Reproductive Status

Formula for Vocalizations and Gender

Each of the different types of vocalizations for each elephant was counted and added together. This was also done for each gender.

Formula for Interactions

Interaction graphs were formed in the same way as graphs in the other categories, which was without separation. The only difference was that the elephants were separated into play groups.

Description of Elephants and Play Groups

Age Categories (years), elephant's name within each age range, and the symbol to identify each elephant.

Infant (0-1) Kala (K)
Juvenile (1-12) Asha (A), Chandra (CH)
Adolescente (13-20) Moola (MO)
Young Adult (20-30) Khun-Chorn (KC), Patience (P), Chai (CI)
Middle Adult (31-60) Minyahk (MI), Onyx (O), Connie (C)

Group 1. **Patience** (Young Adult), **Kala** (Infant)

Patience is Kala's mother. Even though Patience has a calf (which does bring her standing in the herd) she is a subordinate to Minyahk and Connie.

Group 2. **Patience**, **Kala** and **Connie** (Middle Adult), Connie is an experienced mother and has been with Patience for many years.

Group 3. **Connie**, **Moola** (Adolescent),and **Minyahk** (Middle Adult)

Minyahk is on the upper end of the Middle Adult age category. She is coming to the end of her reign as the matriarch. She has never had a calf and cycles irregularly.

Connie is on the lower end of the middle Adult age group and is the next matriarch. She has assumed many of the matriarchal duties.

Moola has had a calf (Chandra). She is an adolescent and is submissive to other females.

Group 4. M**inyahk**, **Asha** (Juvenile), and **Chandra** (Juvenile)

Minyahk was discussed in Group 3. When with the juvenile females, she is their allomother.

Asha is a few years older than Chandra's elder.

Minyahk was their caretaker.

Group 5. **Moola**, **Onyx** (Middle Adult) and **Chai** (Young Adult)

Onyx is an experienced breeding male.

Chai is an outside female sent to the zoo to have her bred to Onyx.

Moola was described in Group 3.

Individual 1. **Khun-Chorn** (Young Adult)

Individual 2. **Onyx** was described in Group 5.

Summary

Chapter VI introduced the subjects as well as the techniques used to implement the different phases of the study. The enrichment items were discussed as was the statistical procedure.

CHAPTER VII

RESULTS

Chapter Rational

Chapter VII contains the results of this study. Graphs, tables, and written descriptions are used for clarification of outcomes

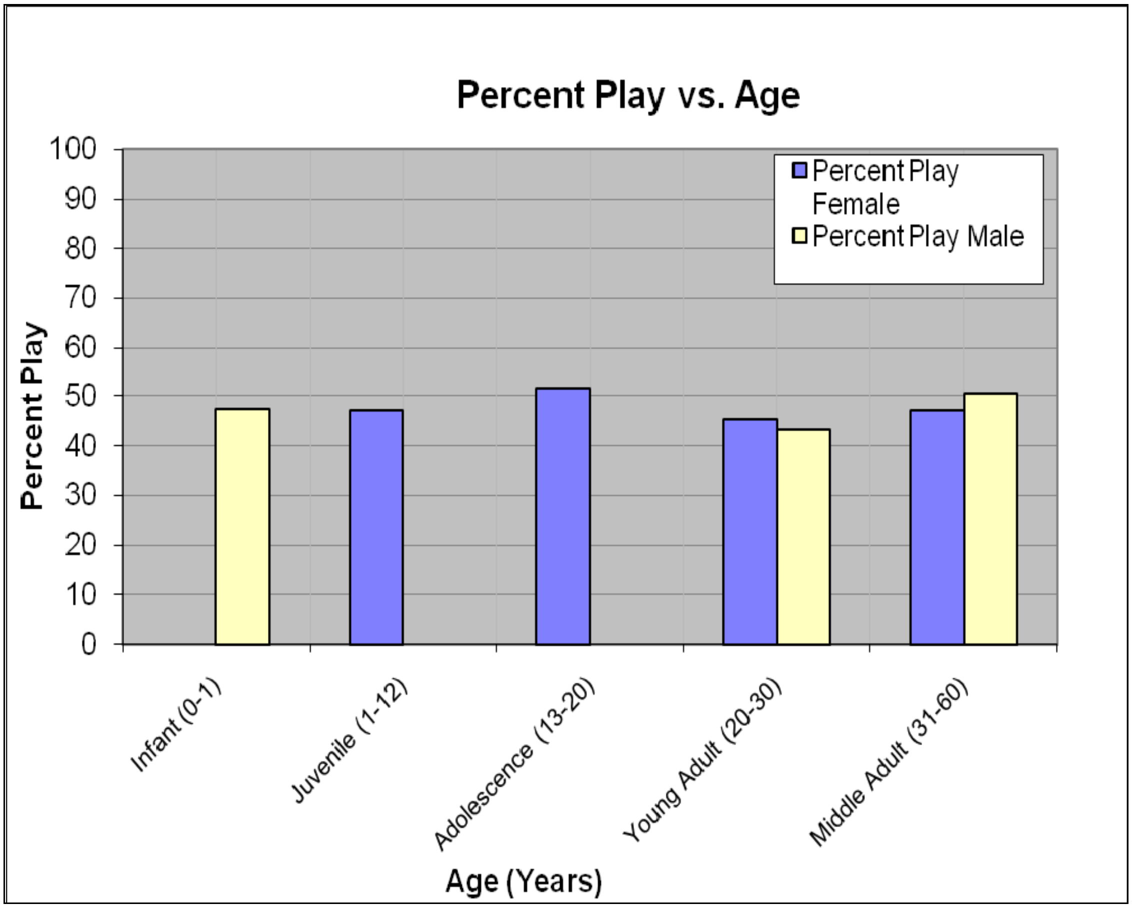
Age

Age Categories (years), elephants' names within each age range, and the symbol for each elephant.

Infant (0-1) Kala (K)
Juvenile (1-12) Asha (A), Chandra (CH)
Adolescente (13-20) Moola (MO)
Young Adult (20-30) Khun-Chorn (KC), Patience (P), Chai (CI)
Middle Adult (31-60) Minyahk (MI), Onyx (O), Connie (C)

Percent Time Spent Playing Sorted by Age Categories

Infant and Juveniles played the same percent of time (47.0%). The Adolescent spent more time playing than any other elephant (52.0%). The Infant, Juveniles, and Adolescente did the highest percentage of play. The next highest was the Middle Adult male with 50.0%. He spent 3.0% more time in play than the Infant male and 7% more than the Young Adult male. The Young Adult male played the least of any of the elephants (Figure 1, Table 1).



igure 1. Percent time spent playing according to age categories. .Infant (0-1 years), Juvenile (1-12 years), Adolescente (13-20 years), Young Adult (20-30 years), Middle Adult (31-60 years).

Table 1. Percent Time Spent Playing Sorted by Age Categories

Age (Years)	Total Play Female (min)	Total Observed Female (min)	Percent Play Female	Total Play Male (min)	Total Observed Male (min)	Percent Play Male
Infant (0-1)	0	0	0.0	25343	53520	47.0
Juvenile (1-12)	106342	224880	47.0	0	0	0.0
Adolescente (13-20)	10547	20480	52.0	0	0	0.0
Young Adult (20-30)	11082	24480	45.0	10495	24240	43.0
Middle Adult (31-60)	49946	105780	47.0	11539	22860	51.0

Vocalizations

Number of Vocalizatons vs. Gender

There were 60 audible vocalizations. Females made 57, the Middle Adult male made 2, and the Infant male made 1. There were 36 Chirps, which was the principal grouping of vocalizations. The next highest was 13 Rumbles, then 7 Roars and 4 Trumpets. There were no Bawls (Figure 2, Table 2).

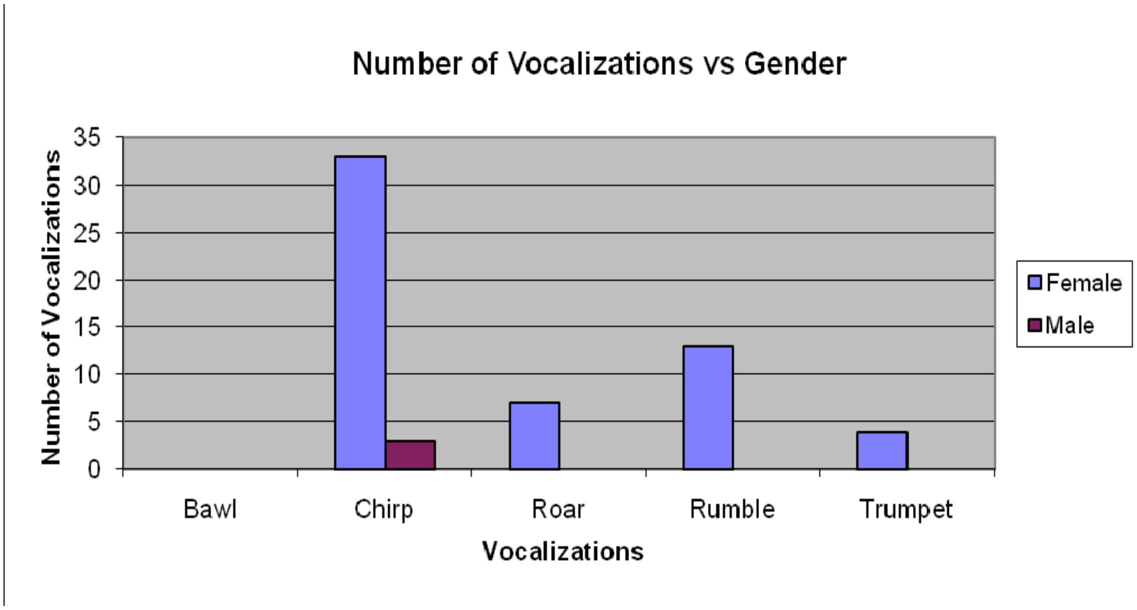


Figure 2. The number of audible validations for each type (Bawl, Chirp, Roar, Rumble, Trumpet) according to gender. There were 60 audible vocalizations.

Table 2. Number of Vocalizations vs. Gender

Gender	Bawl	Chirp	Roar	Rumble	Trumpet
Female	0	33	7	13	4
Male	0	3	0	0	0

Symbol for Five Different Vocalizations. B = Bawl, CP = Chirp, RO = Roar, RU =Rumble, T = Trumpet.

The Number of Each Type of Vocalization Made by the Individual Elephants

The most used type of vocalization was the Chirp (36). Minyahk (MI) made 23 of the 36 Chirps. Connie (C) made most of the Roars (5 of 7) and 5 of the 13 Rumbles. Only Patience made more Rumbles (6). MI made the most vocalizations (24), C was next with 10 and Moola (MO) and Patience (P) made 7 each. Onyx (O) made the most vocalizations of the males with 2 and Kala (K) was the next for males with 1. No Bawls were made by any of the elephants (Figure 3, Table 3).

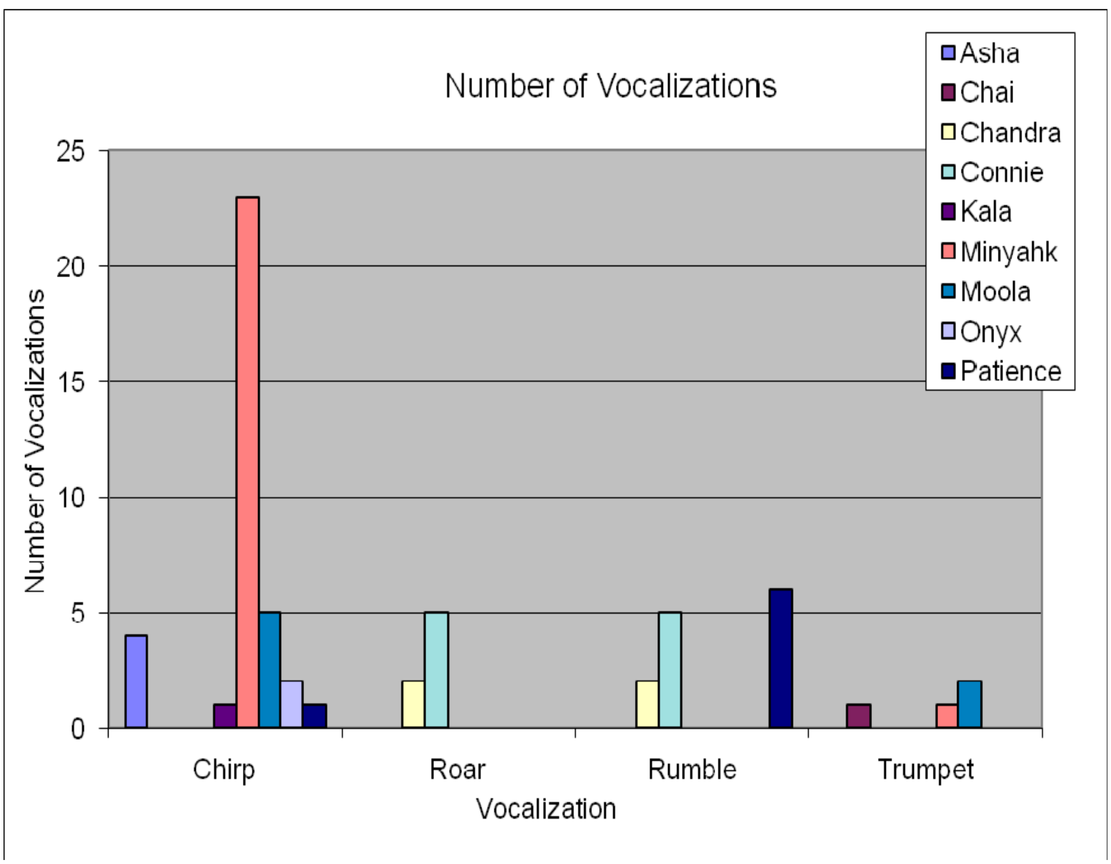


Figure 3. The number of each type of vocalization (Chirp Roar, Rumble, Trumpet, and Bawl) made by the individual elephants. There were no Bawls made by any of the elephants.

Table 3. The Number of Each Type of Vocalizations Made by the Individual Elephants

Elephant's Name	Chirp	Roar	Rumble	Trumpet
Asha	4	0	0	0
Chai	0	0	0	1
Chandra	0	2	2	0
Connie	0	5	5	0
Kala	1	0	0	0
Minyahk	23	0	0	1
Moola	5	0	0	2
Onyx	2	0	0	0
Patience	1	0	6	0

Vocalization and Their Implications for the Interaction of Individual Elephants Within Play Groups

All of the Chirps MI produced (23) were done when she was playing with the two Juvenile females, Asha and Chandra (CH). Asha also made 4 chirps during the same period of time. The next most- used vocalization was the Rumble (13). C produced 5 Rumbles and only when she was with P and K (mother/son). P Rumbled 6 times, 3 when with K alone and 3 when C was with them. C Roared 4 times when with Onyx (O) and Chai (CI) and 1 time when with Moola (MO) and MI. O Chirped twice, once when he was with MO and CI and once when with C and CI. The Infant male, K made 1 Chirp when with P. The females made 57 of the 60 vocalizations (Figure 4, Table 4).

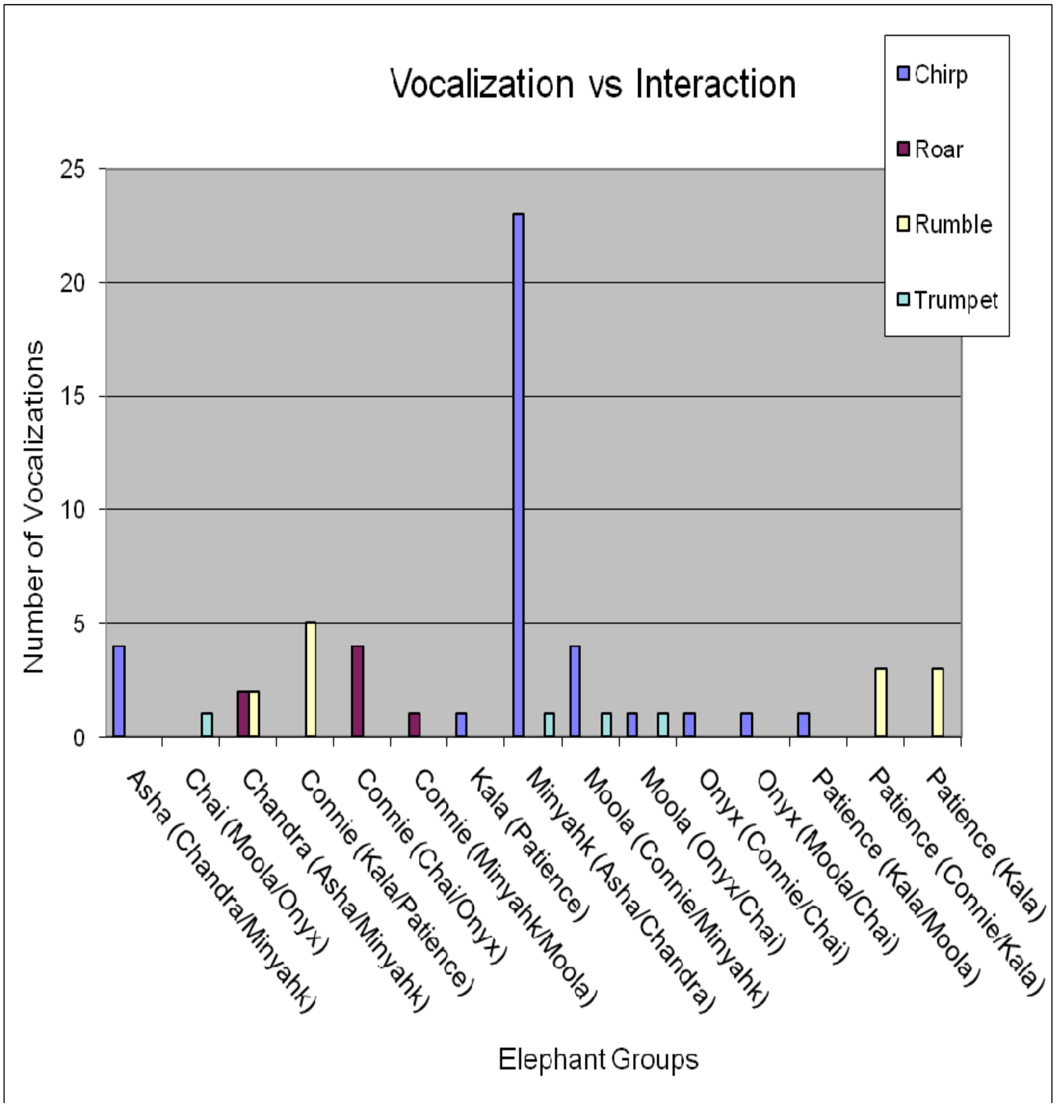


Figure 4. Vocalizations of Individual Elephants Within Play Groups are Measured to Assess How those Vocalizations Impact the Interactions of Individuals Within the Group.

Table 4. Vocalizations and Their Implications for the Interaction of Individual Elephants within Play Groups

Elephant 's Name	Chirp	Roar	Rumble	Trumpet
Asha (Chandra/Minyahk)	**4**	**0**	**0**	**0**
Chai (Moola/Onyx)	**0**	**0**	**0**	**1**
Chandra (Asha/Minyahk)	**0**	**2**	**2**	**0**
Connie (Kala/Patience)	**0**	**0**	**5**	**0**
Connie (Chai/Onyx)	**0**	**4**	**0**	**0**
Connie (Minyahk/Moola)	**0**	**1**	**0**	**0**
Kala (Patience)	**1**	**0**	**0**	**0**
Minyahk (Asha/Chandra)	**23**	**0**	**0**	**1**
Moola (Connie/Minyahk)	**4**	**0**	**0**	**1**
Moola (Onyx/Chai)	**1**	**0**	**0**	**1**
Onyx (Connie/Chai)	**1**	**0**	**0**	**0**
Onyx (Moola/Chai)	**1**	**0**	**0**	**0**
Patience (Kala/Moola)	**1**	**0**	**0**	**0**
Patience (Connie/Kala)	**0**	**0**	**3**	**0**
Patience (Kala)	**0**	**0**	**3**	**0**

Time Spent Playing

Gender and Percent of Time Spent Playing

Both males and females played 48.0% of the time they were offered the enrichment item (Figure 5, Table 5).

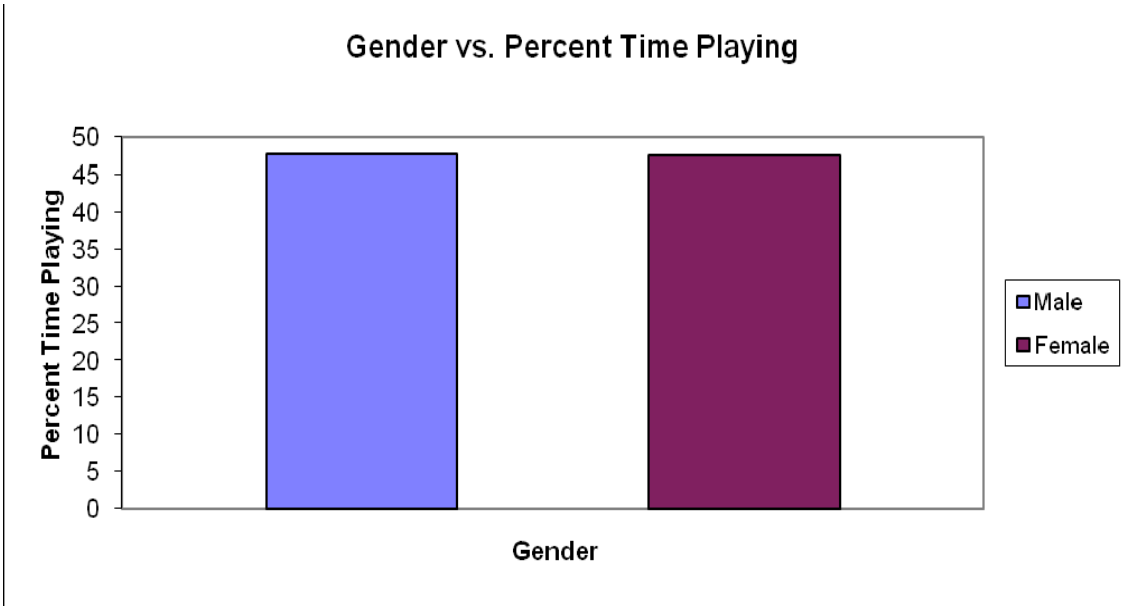


Figure 5. Total time (min) males played divided by total observed time provided the percent of time males played. Total time (min) females play divided by total time observed provided the percent of time females played.

Table 5. Gender and Percent of Time Spent Playing

Gender	Total Observed (min)	Total Time Playing (min)	Percent Play
Male	100860	48128	48.0
Female	372360	177166	48.0

Percent of Time Elephants Spent Playing with the

Individual Enrichment Items

Fifure 6 and Table 6 rate the enrichment items by total percentage of time that was spent playing with each item (most to least used). Browse (BR) was used 40.0% of the time, the Fiddle Chain (FC) 20.0%, the Tire (TI) 17.0%, the Chimes (CM) 14.0%, and the Pin Wheel (PW), used only by MI, CH and Asha, 7.0 % (Figure 6, Table 6).

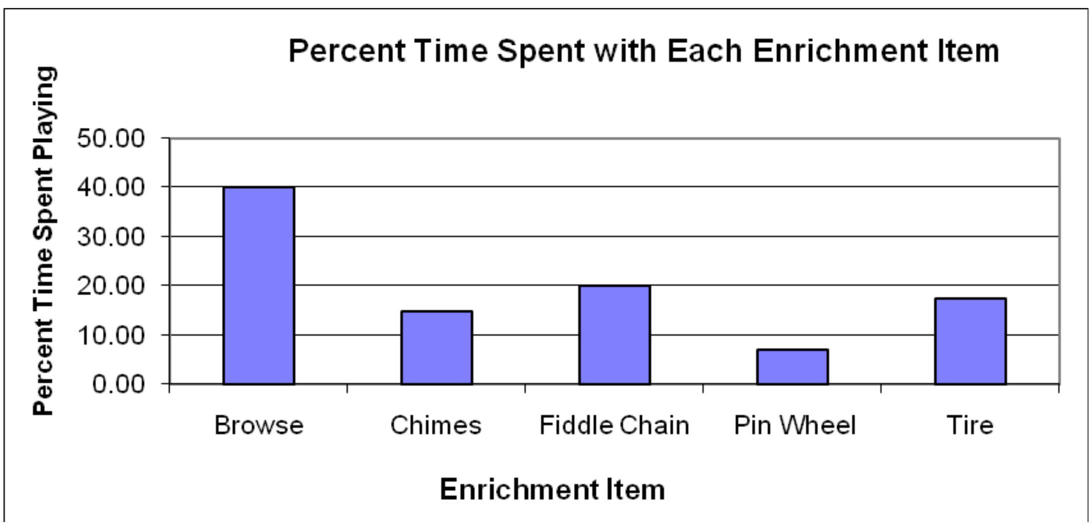


Figure 6. Time spent with each enrichment item individually. The Pin Wheel (PW) was offered only to the group with MI, CH, and Asha. None of the other elephants were exposed to it.

Table 6. Percent of Time Elephants Spent Playing with the Individual Enrichment Items

Total Toys (min)	Browse	Chimes	Fiddle Chain	Pin Wheel	Tire
2326990	40	15	20	7	17

Symbol for Enrichment Item.
BR = Browse, CM = Chimes, FC = Fiddle Chain, TI =Tire, PW = Pin Wheel

Percent of Time Individual Elephants Spent with

Each Enrichment Item

Asha spent 29.0% of the time playing with Browse, 20.0% with Chimes, 20.0% with the Fiddle Chain, 17.0% with the Pin Wheel and 14.0% with the Tire. She played equally with each enrichment item but showed a little more interest in Browse. Of the three elephants that played with the Pin Wheel, Asha spent the most time with it (17.0%), CH spent 11.0% and MI only 5.0%. CI spent 76.0% of the time with Browse; Chimes, 16.0%, and Tire, 12.0%. CH spent 31.0% of the time with Browse, 23.0% with the Fiddle chain, 19.0% with the Chimes, 15.0% with the Tire, and only 10.0% with the Pinwheel. C used the Fiddle Chain 38.0% of the time; Browse, 34.0%; Chimes , 20.0% ;and Tire, 9.0% of the time. K spent 40.0% of the time with Browse, 33.0% with the Tire and 27.0% with the Fiddle Chain. He did not play with the Chimes at all.

Khun-Chorn (KC) preferred Browse 39.0% of the time; the Tire, 35.0%; and the Chimes 26.0% of the time. MI preferred Browse 56.0% of the time spent playing, 15.0%

with the Fiddle Chain, 13.0% with the Tire, 13.0% with the Chimes, and 5.0% with the Pinwheel (she was the only adult that experienced it). MO spent 60.0% of her time playing with the Browse, 18.0% with the Chimes, 11.0% with the Tire, and only 10.0% with the Fiddle Chain. O used Browse 62.0% of time, 19.0% with the Fiddle Chain, 11.0% with the Tire and 7.0% with Chimes. P did not play with the Chimes at all, and spent 51.0% of time with Browse, 26.0% with the Tire, and 23.0% with the Fiddle Chain (Figure 7, Table 7).

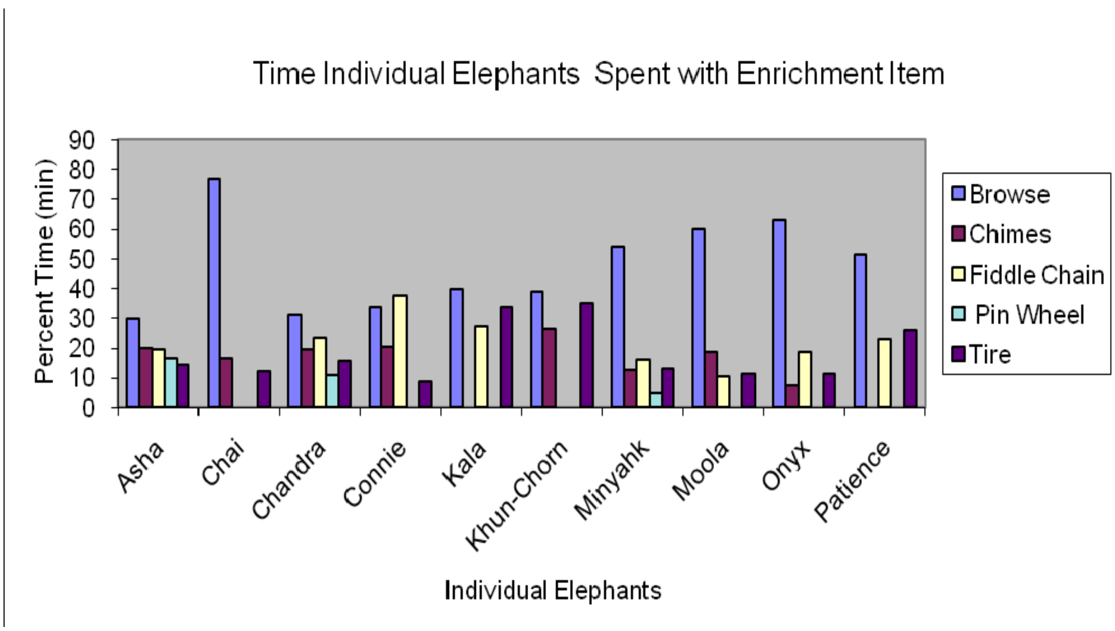


Figure 7. The percentage of time individual elephants spent playing with each enrichment item. PW shows only for MI, Asha, and CH

Table 7. Percent of Time Individual Elephants Spent with Each Enrichment Item

Elephant's Name	Total Play Behaviors (min)	Percentage of Time with Browse	Percentage of Time with Chimes	Percentage of Time with Fiddle Chain	Percentage of Time with Pin Wheel	Percentage of Time with Tire
Asha	58263	30.0	20.0	20.0	17.0	14.0
Chai	3905	77.0	16.0	0.0	0.0	12.0
Chandra	48189	31.0	19.0	23.0	11.0	16.0
Connie	14068	34.0	20.0	38.0	0.0	9.0
Kala	25310	40.0	0.0	28.0	0.0	33.0
Khun-Chorn	10795	37.0	26.0	0.0	0.0	35.0
Minyahk	36252	54.0	13.0	16.0	4.8	13.0
Moola	10788	60.0	18.0	11.0	0.0	11.0
Onyx	11964	63.0	7.0	19.0	0.0	11..0
Patience	12700	51.0	0.0	23.0	0.0	26.0

Enrichment Items and Their Influence on the Interactions

Of Individual Elephants Within Play Groups

When P & K were by themselves in their group, they were both interested in Browse, P 45.0% of the time and K 30.0% . When they were in with MO, their interest fell off to 0.0%, as did MO's. When they were in with C, P's interest in Browse was 6.0% and K's 9.0%, while C's was 30.0%. K had 0.0% interest in the Tire when he was with P alone, but when C was with them, his interest was 7.0% and when they were with MO, his interest was 27.0%. C was interested in the Tire 2.0% of the time and MO played with it 12.0%.

That was the only time MO played with the Tire. C played with it only when in The group with O and CI, and that was 6.0% of the time. K did not play with the Fiddle Chain when with P alone, but when C was with them, he played with it 21.0% and when with MO, he played with it 7.0% of the time. C played with the Fiddle Chain 38.0% of the time when with P and K and not at all when she was not with them. This was the only time MO, played with it, and that was for 11% of the time.

CH mirrored Asha's play behaviors except for a slight preference for the Fiddle chain of 23.0% to Asha's 19.0%. Asha had a little more interest in the Pin Wheel (19.0%), while CH only played with it 10.0 % of the time. MI played most of her time when with these two: 45.0%, Browse; 11.0%, Chimes; 16.0%, Fiddle Chain; 21.0%, Pin Wheel; and 13.0% Tire. The only other time she played was 9.0% Browse and 3.0% Chimes when with C & MO. The only play C did was when she was with O and CI was (9.0% Chimes and 6.0% Tire) and with MI and MO (27.0% Browse and 4.0% Chime). CI's only play was when with O and MO (Browse 76.0%) and when with C and O (19.0% Chimes and 7.0% Tire). KC was always alone with no interactions with other elephants. MO played only with Browse 26.0% and Chimes 18.0 % when with C and MI and only Browse 34.0% when with O and CI. When O was by himself, he played with Browse 32.0% and FC, 19.0%. When he was with C and CI, he used the Chimes 7.0% of time and spent 1.0% with the Tire, but when with MO and CI, Browse 30.0% of the time (Figure 8, Table 8).

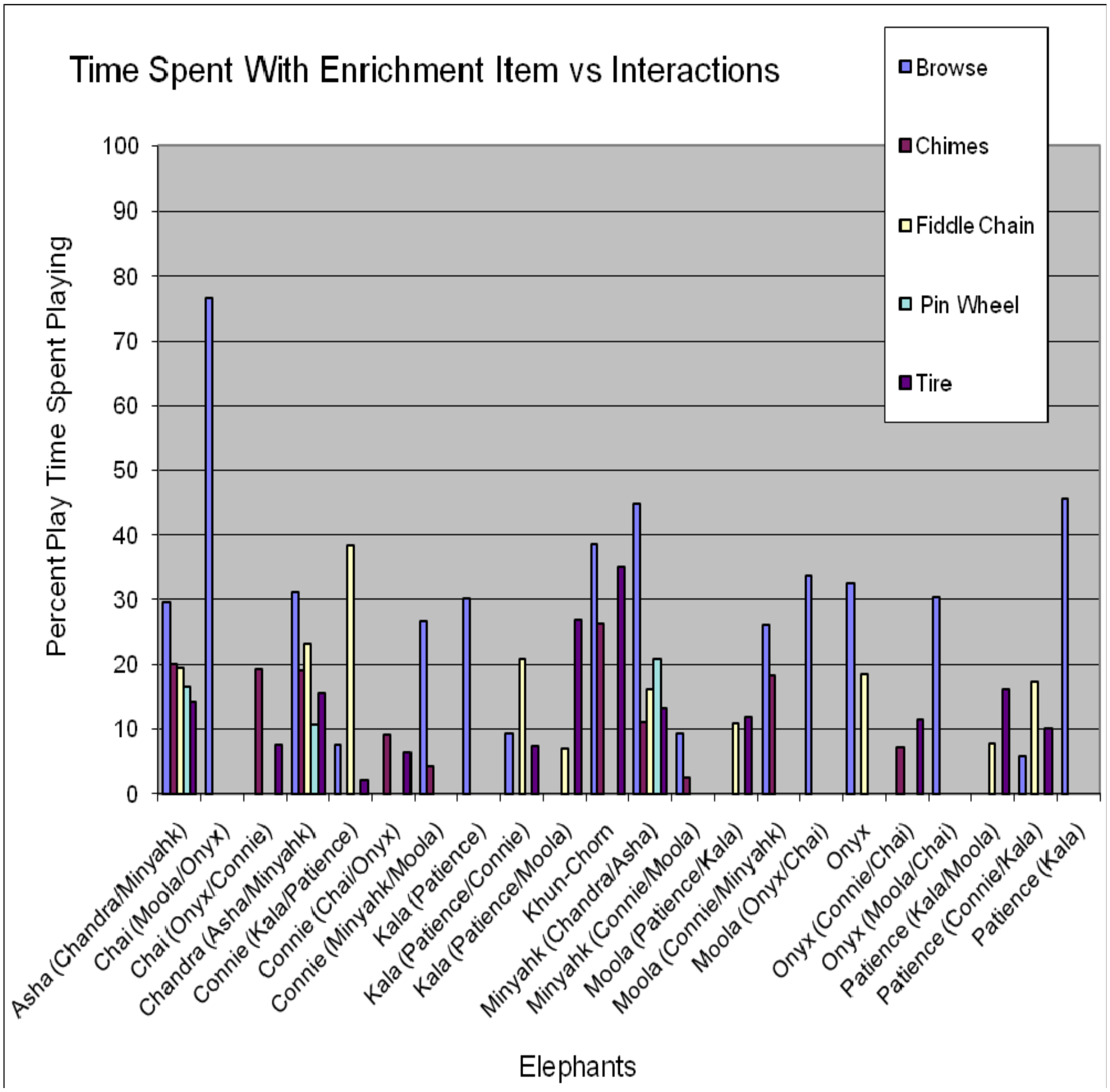


Figure 8. Percent of Time Spent Playing by Each Elephant in their Play Group and the Enrichment Item Each Played With.

Table 8 Enrichment Item and its Influence on the Interaction of Individual Elephants within Play Groups Relative to Percent of Time Spent Playing with Each Item

Elephant's Name	**Total Play Behaviors (min)**	**Percentage of Browse**	**Percentage of Chimes**	**Percentage of Fiddle Chain**	**Percentage of Pin Wheel**	**Percentage of Tire**
Asha (Chandra/Minyahk)	58263	30.0	20.0	20.0	17.0	14.0
Chai (Moola/Onyx)	3773	77.0	0.0	0.0	0.0	0.0
Chai (Onyx/Connie)	3773	0.0	19.0	0.0	0.0	78.0
Chandra (Asha/Minyahk)	48189	31.0	19.0	23.0	11.0	16.0
Connie (Kala/Patience)	14110	8.0	0.0	38.0	0.0	2.0
Connie (Chai/Onyx)	14110	0.0	9.0	0.0	0.0	6.0
Connie (Minyahk/Moola)	14110	27.0	4.0	0.0	0.0	0.0
Kala (Patience)	25343	30.0	0.0	0.0	0.0	0.0
Kala (Patience/Connie)	25343	9.0	0.0	21.0	0.0	7.0
Kala (Patience/Moola)	25343	0.0	0.0	7.0	0.0	27.0
Khun-Chorn	10795	39.0	26.0	0.0	0.0	35.0
Minyahk (Chandra/Asha)	36426	45.0	11.0	16.0	21.0	13.3
Minyahk (Connie/Moola)	36426	9.0	2.0	0.0	0.0	0.0
Moola (Patience/Kala)	10576	0.0	0.0	11.0	0.0	12.0
Moola (Connie/Minyahk)	10576	26.0	18.0	0.0	0.0	0.0
Moola (Onyx/Chai)	10576	34.0	0.0	0.0	0.0	0.0
Onyx	12062	33.0	0.0	19.0	0.0	0.0
Onyx (Connie/Chai)	12062	0.0	7.0	0.0	0.0	11.0
Onyx (Moola/Chai)	12062	30.0	0.0	0.0	0.0	0.0
Patience (Kala/Moola)	13156	0.0	0.0	8.0	0.0	16.0
Patience (Connie/Kala)	13156	6.0	0.0	17.0	0.0	10.0
Patience (Kala)	13156	46.0	0.0	0.0	0.0	0.0

Play Behavior

Percent Play Behavior of the Different Manipulations

From the most- used play behavior to the least, the elephants used their Trunks 64.0% of the time playing with the objects. In addition they used their Mouths 15.0%, their Foot 13.0%, Head 4.0 %, Striking 2.0% and Blowing 0.6% of the time (Figure 9 Table 9).

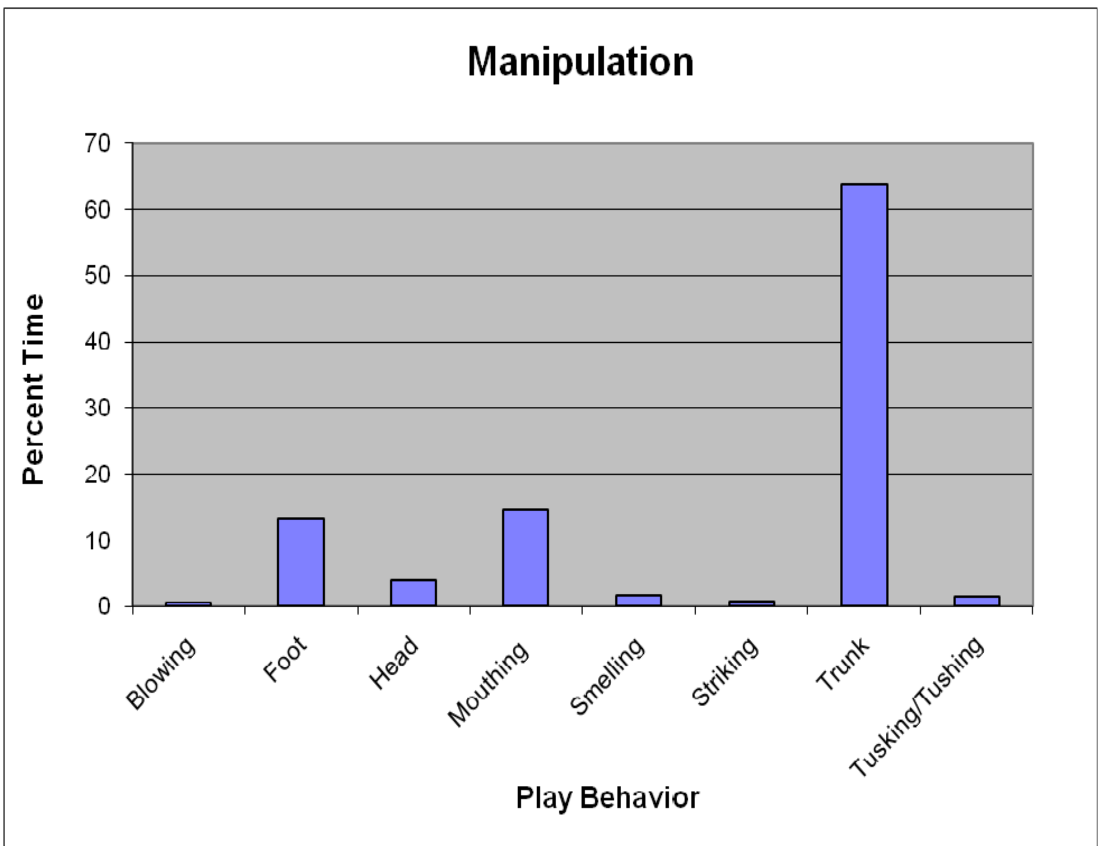


Figure 9. Percentage of total time spent using each play behavior while playing.

Table 9. Percent Play Behavior of the Different Manipulations

Total Play Behaviors (min)	Percent Blowing	Percent Foot	Percent Head	Percent Mouthing	Percent Smelling	Percent Striking	Percent Trunk	Percent Tusking/Tushing
177086	0.6	13.0	4.0	15.0	1.5	0.7	64.0	1.5

Percent of Individual Manipulations by Each Elephant

K (Infant) spent 29.0% of the time manipulating an enrichment item using a Foot; 14.0% using the Head, 11.0%, Mouthing; and 43.0% using the Trunk. Chandra (Juvenile) spent 12.0% of the time uses a Foot; 17.0%, Mouthing; and 65.0%, using the Trunk. Asha (Juvenile) played using her Trunk 62.0% of the total time spent playing; Mouthing, 17.0%; and using the Foot, 16.0% of the time. MO (Adolescent) spent 3.0% of the time using Foot; 13.0%, Mouthing; 78.0%, using the Trunk and less than 2.0% using the Head, Smelling, Tushing, and Striking. Patience (Young Adult) used her Foot 10.0 % of the time; 6.0%, Smelling; and 85.0%, the Trunk. These were the only three behaviors she used. P, MO, and KC (Young Adult) used only 3 behaviors and spent 15.0% of the time using the Foot; 2.0% striking; and 84.0% using the Trunk. Chai (Young Adult) used her Foot 3.0%; Smelling 18.0% (the most of all the elephants); and 79.0% the Trunk. These were the only three behaviors she used. Onyx (Middle Adult) used 7.0% Blowing; 2.5%, Mouthing; 8.0%, Smelling; 78.0 %, Trunk; and 3.0%, Tusking when he played. Connie

(Middle Adult) used the Foot 18.0%; 11.0% Mouthing; 2.0 % Smelling; 3.0% Striking; and 65.0% the Trunk. Minyahk (Middle Adult) used 2.0% Blowing; 3.0 %, Foot; 13.0%, Mouthing; 2.0%, Smelling; 76.0%, Trunk; and 3.0%, Tushing (Figure 10, Table 10).

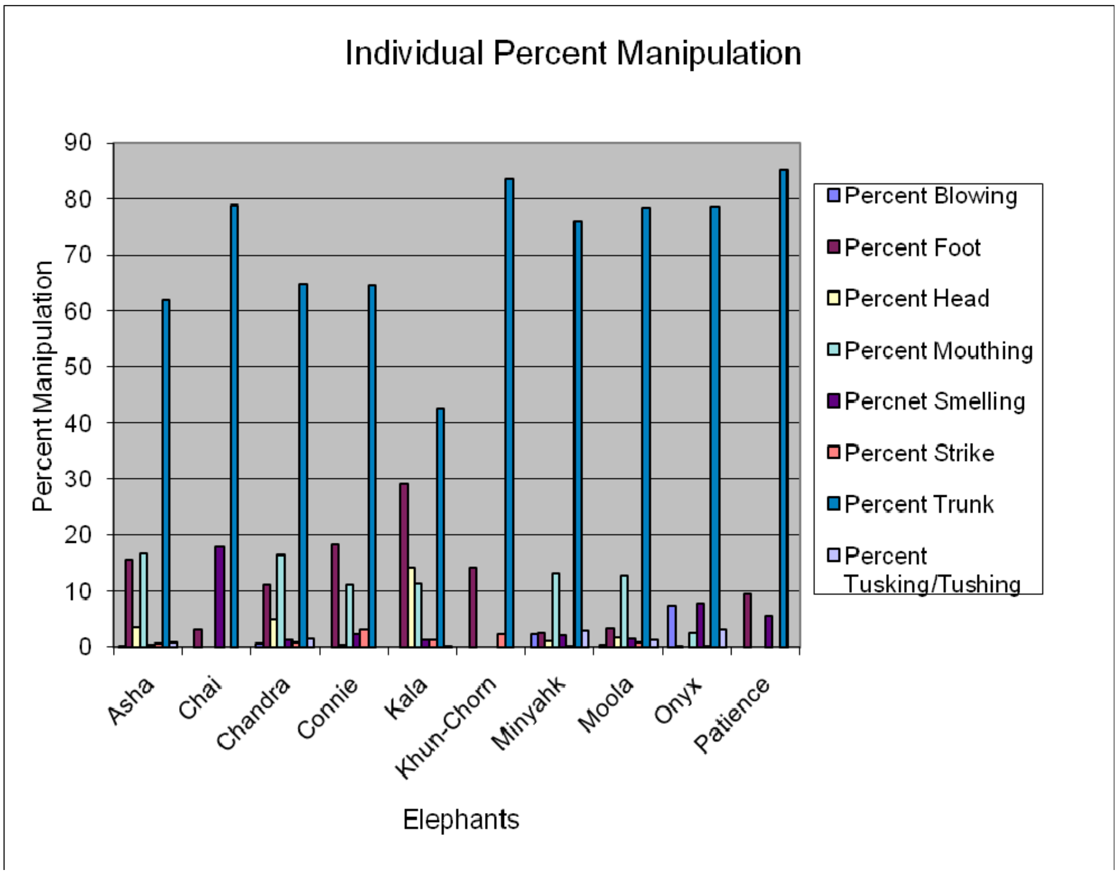


Figure 10 Percent of Times Individual Elephants Used Each Play Behavior While Playing.

Table 10. Percent of Individual Manipulations by Each Elephant

Elephant's Name	Percent Blowing	Percent Foot	Percent Head	Percent Mouthing	Percent Smelling	Percent Strike	Percent Trunk	Percent Tusking/Tushing
Asha	0.3	16.0	4.0	17.0	0.5	0.6	62.0	0.78
Chai	0.0	3.0	0.0	0.0	18.0	0.0	79.0	0.0
Chandra	0.7	11.0	5.0	17.0	1.0	1.0	65.0	2.0
Connie	0.0	18.0	0.4	11.0	2.0	3.0	65.0	0.0
Kala	0.0	29.0	14.0	11.0	1.0	1.0	43.6	0.3
Khun-Chorn	0.0	14.0	0.0	0.0	0.0	2.0	84.0	0.0
Minyahk	2.2	23.0	1.0	13.0	2.0	0.2	76.0	3.0
Moola	0.0	3.0	2.0	13.0	2.0	0.78	78.0	1.0
Onyx	7.4	0.2	0.0	3.0	8.0	0.3	79.0	3..0
Patience	0.0	10.0	0.0	0.0	6.0	0.0	85.0	0.0

Percent of Play Behavior While Elephants Were Interactihg

In their Play Groups

When C was with P and K, she used her Foot 12.0% of time; Mouth, .3.0%; Smelling, 2.0%; Strike, 3.0%; and Trunk, 27.0%. When she was with O and CI, she used Mouth 3.0% of the time, and Trunk, 7.0%. When she was with MO and MI, she used Foot 7.0% of the time; Mouth, 4.0%; Strike, 0.5%; and Trunk, 31.0%.

MI spent 3.0% of her time Tushing when she was with Asha and CH. Besides O, MI is the only other elephant that utilized Blow as a play behavior, and she used it only when with A and CH. Most of her other play behaviors (Foot 2.0%, Mouthing 13.0%, Smelling 2.0% and Trunk 68.0%) were done when she was with Asha and CH. When with C and MO she used 0.2% Foot, 0.4% Mouthing, and 8.0% Trunk.

Again Asha and CH mirrored one another. Asha's percent is first followed by CH's: (Blowing, 0 .3% to 0.7%; Foot, 16.0% to 11.0%; Head, 4.0% to 5.0%; Mouthing, 17.0% to 17.0%; Smelling, 0.5% to 1.0%; Strike, 64.0% to .8.0%; Trunk, 62.0% to 65.0; and Tushing, 0.76 to 2.0%. Their play behavior patterns are very similar.

While K was with P alone, his play behaviors were Foot, 2.0%; Head, .0.3%; Smelling, 0.5%; Trunk,19.0%; and Tusking, 14.0%. When with C his behaviors were Foot, 8.0%; Head, 0.27%; Mouthing, 7.0 %; Smelling, 0.1%, Strike 1.0%; Trunk, 15.0%; and Tusking 12.0%. When MO was with K and P, he used Foot, 11.0%; Head, 9.0%; Mouthing, 4.0%; Smelling, 1.0%; Striking, 0.2%; and Trunk, 14.0%,.

P used her Foot 7.0% when with only K, 3.0% when C was with them and only 10.0% when she was in with MO and K. She used Mouthing 2.0% when with MO and 3.0% when C was with her and K. The only other behavior she exhibited was Trunk, 8.0% when MO was there, 15.0% with C and 63.0% when it was just P and K.

The only behaviors KC used were Foot 14.0%, Strike 2.0% and Trunk 84.0.

CI used Smelling (18.0%) only when with MO and O. She used her Trunk 66.0% when with them, but when C was in with them, she used it 13.0% of the time.

O used Blowing (7.0%) Foot (.21.0%), Mouthing (3.0%), Trunk (33.0%), and Tusking (3.0%) when alone. When he was with C and CI, he used Smell (2.0%), Strike (28.0%), and Trunk (4.0%). When MO and CI were with him, he used only his Trunk, 42.0% of the time (Figure 11. Table 11)

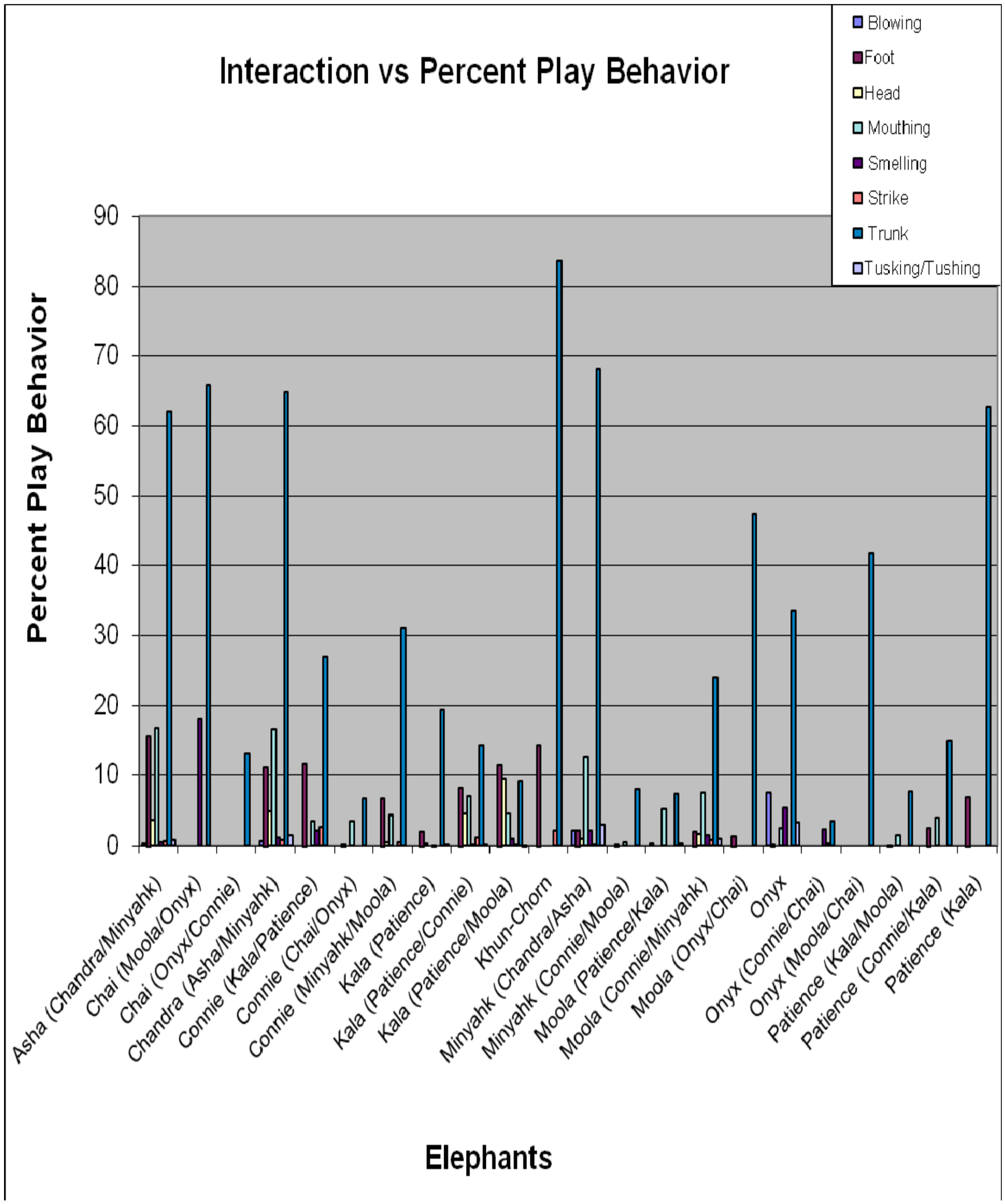


Figure 11. Percent of Play Behaviors that were Exhibited by Individual Elephants as they Interacted in Their Play Groups.

Table 11. Percent of Play Behavior while Elephants were Interacting in their Play Groups

Elephant's Name	Blowing	Foot	Head	Mouthing	Smelling	Strike	Trunk	Tusking Tushing
Asha (Chandra/Minyahk)	0.3	16.0	4.0	17.0	0.5	0.6	62.0	0.8
Chai (Moola/Onyx)	0.0	0.0	0.0	0.0	18.0	0.0	66.0	0.0
Chai (Onyx/Connie)	0.0	0.0	0.0	0.0	0.0	0.0	13.0	0.0
Chandra (Asha/Minyahk)	0.7	11.0	5.0	17.0	1.0	0.8	65.0	2.0
Connie (Kala/Patience)	0.0	12.0	0.0	3.0	2.0	3.0	27.0	0.0
Connie (Chai/Onyx)	0.0	0.2	0.0	3.0	0.0	0.0	7.0	0.0
Connie (Minyahk/Moola)	0.0	7.0	0.4	4.0	0.0	0.5	31.0	0.0
Kala (Patience)	0.0	2.0	0.3	0.0	0.05	0.00	19.0	0.1
Kala (Patience/Connie)	0.0	8.0	4.0	7.0	0.1	1.0	14.0	0.1
Kala (Patience/Moola)	0.0	11.0	9.0	4.0	1.0	0.2	9.0	0.0
Khun-Chorn	0.0	140	0.0	0.0	0.0	2.0	84.0	0.0
Minyahk (Chandra/Asha)	2.0	2.0	1.0	13.0	2.2	0.2	68.0	3.0
Minyahk (Connie/Moola)	0.0	0.2	0.0	0.4	0.0	0.0	8.0	0.0
Moola (Patience/Kala)	0.40	0.0	0.0	5.0	0.0	0.0	7.2	0.3
Moola (Connie/Minyahk)	0.0	2.0	2.0	8.0	2.0	0.8	24.0	1.0
Moola (Onyx/Chai)	0.0	1.0	0.0	0.0	0.0	0.0	47.0	0.0
Onyx	7.0	0.2	0.0	3.0	5.0	0.0	33.0	3.0
Onyx (Connie/Chai)	0.0	0.0	0.0	0.0	2.0	0.3	3.0	0.0
Onyx (Moola/Chai)	0.0	0.0	0.0	0.0	0.0	0.0	42.0	0.0
Patience (Kala/Moola)	0.0	0.1	0.0	2.0	0.0	0.0	8.0	0.0
Patience (Connie/Kala)	0.0	3.0	0.0	4.0	0.0	0.0	15.0	0.00
Patience (Kala)	0.0	7.0	0.0	0.0	0.0	0.0	63.0	0.0

Submissive and Aggressive Behavior

Percent of Time Spent Using Submissive and Aggressive Behavior According to Gender

Males use the behavior designated as aggressive 45.0% of the time playing and submissive behaviors 55.0% of time. Females use the behavior designated as aggressive 43.0% of the time playing and submissive behavior 57.0% of the time. There is a 14.0% difference (Figure 12, Table 12). There is very little difference between the Male and the Females.

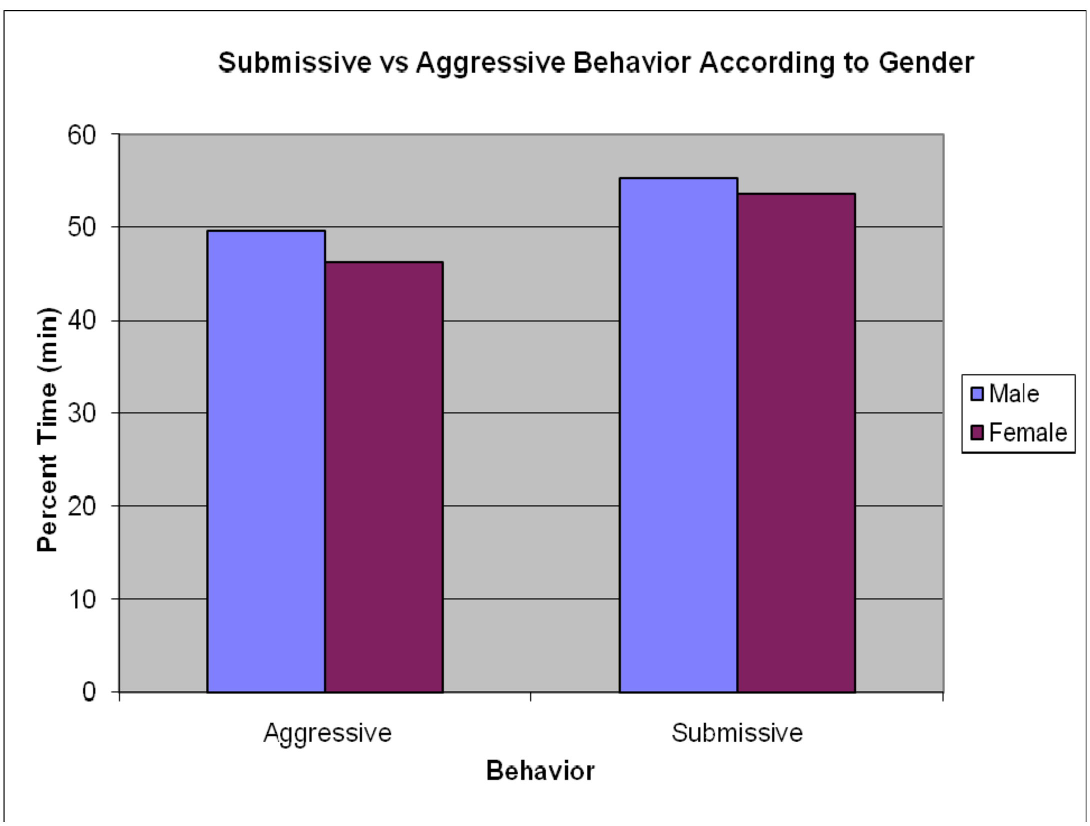


Figure 12   Percent of total submissive and aggressive behavior within the gender.

Table 12. Percent of the Time Spent Using Submissive and Aggressive Behavior According to Gender

Gender	Aggressive	Submissive
Male	45.0	55.0
Female	43.0	57.0

Submissive Behaviors (SB): Defecation, Present Rear, Retreat, Urination.
Aggressive Behaviors (AB): Approach, Charge, Throwing, Strike, Tushing/Tusking

Total Time Each Submissive and Aggressive Behaviors was Exhibited During Play

Females used both Approach AB and Retreat SB more than males

Males used Charge, Defecation, Present Rear, Strike, and Urination more than Females (Figure 13, Table 13).

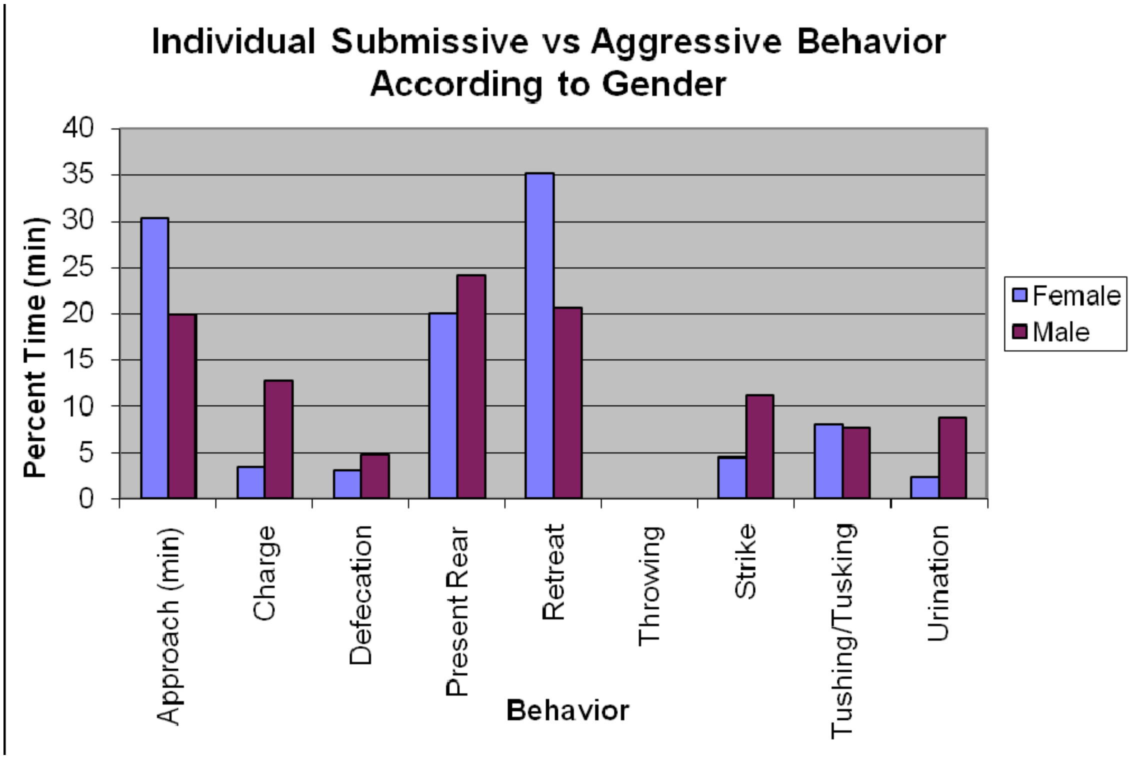


Figure 13. Percent of Individual Submissive and Aggressive Play Behaviors Based on Gender.

Table 13. Total Time Each Submissive and Aggressive Behavior was Exhibited During Play

Gender	Approach	Charge	Defecation	Present Rear	Retreat	Throwing	Strike	Tushing/ Tusking	Urination
Female	29.0	3.0	3.0	19.0	33.0	0.0	4.0	8.0	2.0
Male	20.0	13.0	5.0	24.0	21.0	0.0	11.0	8.0	9.0

Percent Submissive vs. Aggressive Behavior for

Individual Elephants

The percentage of time each elephant was engaging in Submissive or Aggressive Behaviors while playing is shown in (Figure 14, Table 14).

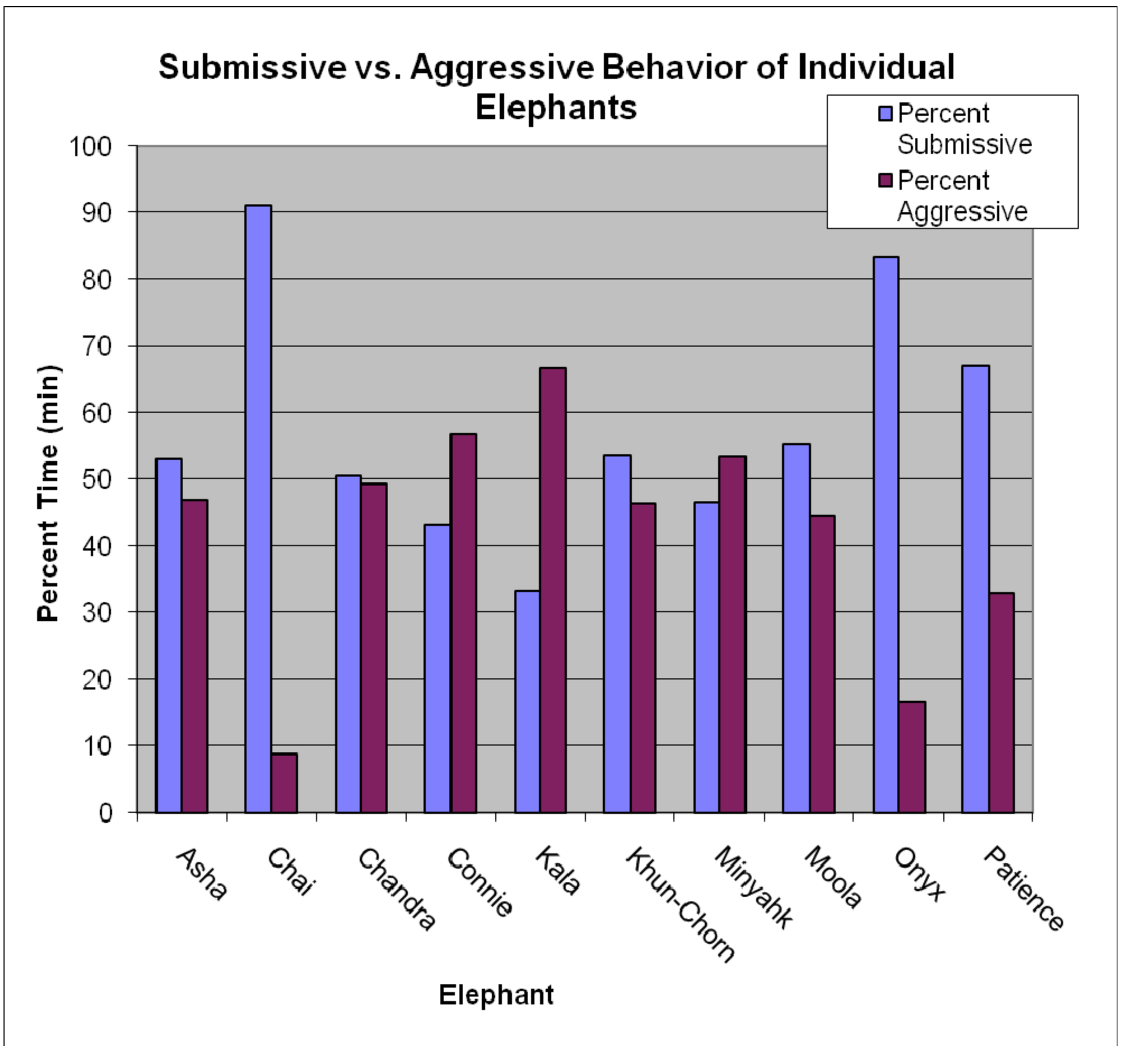


Figure 14. Percentage of Time Submissive and Aggressive Behaviors were Exhibited by the Individual Elephants.

Table 14. Percent Submissive vs. Aggressive Behavior of Individual Elephants

Elephant Name	Percent Submissive	Percent Aggressive
Asha	53.0	47.0
Chai	96.0	4.0
Chandra	51.0	49.0
Connie	43.0	57.0
Kala	33.0	67.0
Khun-Chorn	54.0	46.0
Minyahk	47.0	53.0
Moola	55.0	45.0
Onyx	83.0	17.0
Patience	67.0	33.0

Percent of Time Individual Elephants Displayed Each Submissive and Aggressive Behavior

Asha displayed Approach, 34.0%; Retreat, 27.0%; and Present Rear, 20%.

CH used Approach, 32.0%; Charge, 7.0%; Present Rear, 14.0%; Retreat, 34.0%; and Tush, 7.0%.

MI used Approach, 24.0%; Present Rear, 18.0%; Retreat, 23.0%; and Tush, 28.0%.

CH demonstrated Approach, 9.0%; Defecation, 4.0%; Present Rear, 63.0%; and Urination, 4.0%.

C exhibited 36.0% Approach; Defecation, 6.0%; Present Rear, 16.0%; Strike, 21.0%; and Urination, 9.0 %.

K displayed 23.0% Approach behavior; 25.0%, Charge; 27.0%, Retreat; and 16.0%, Strike.

KC used 13.3% Approach, 10.7% Defecation, 26.6 Retreat, 33% Strike, and 16.2% Urination.

MO utilized 26.0% Approach, 32.0% Present Rear, and 23.0% Retreat, 7.1.0% Strike, and 12.0% Tushing

O exhibited 6.0% Defecation, 59.0% Present Rear, 15.0% Tusking, and 15.0% Urination.

P Approached, 33.0%; Defecated, 7.0%, Retreated, 44.0%; and Urinated, 10.0% (Figure 15, Table 15).

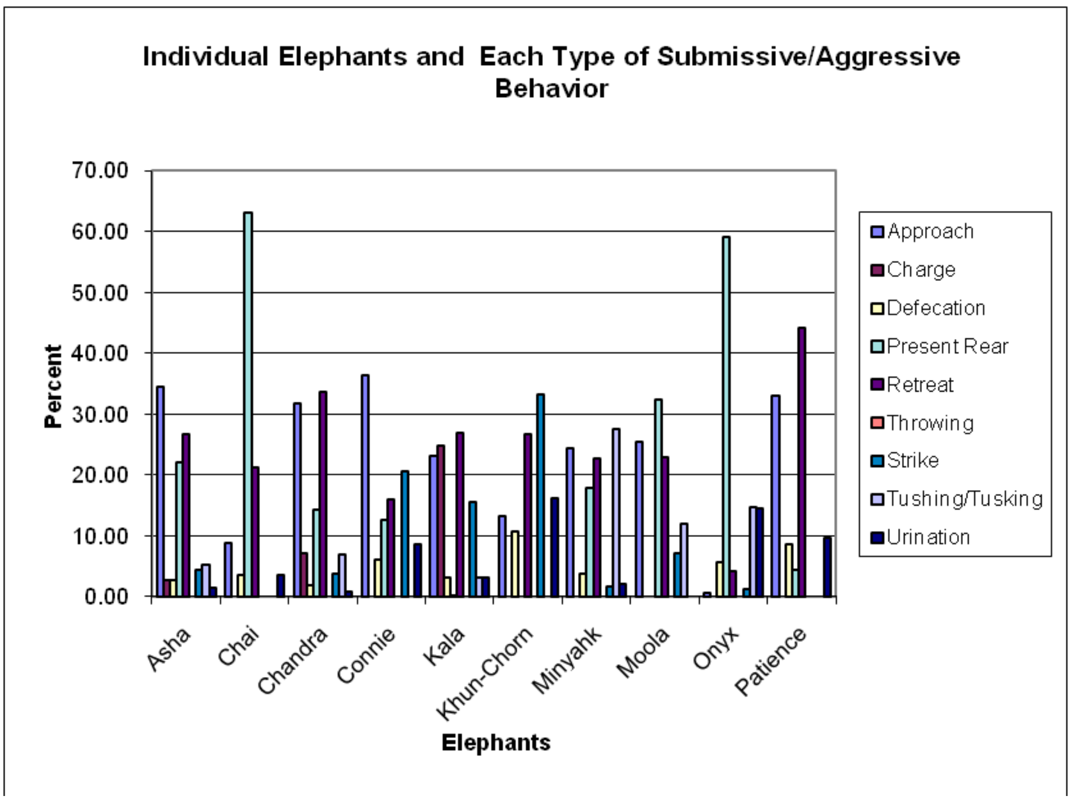


Figure 15. Percent of Each Submissive and Aggressive Behavior Displayed by Each Elephant..

Table 15. Percent Individual Elephant Submissive and Aggressive Behavior

Elephant's Name	Percent Approach	Percent Charge	Percent Defecation	Percent Present Rear	Percent Retreat	Percent Throwing	Percent Strike	T Percent ushing/Tusking	Percent Urination	Total Submissive/Aggressive (min)
Asha	34.0	3.0	3.0	22.0	27.0	0.0	5.0	5.0	2.0	6974
Chai	9.0	0.0	4.0	63.0	21.0	0.0	0.0	0.0	4.0	1404
Chandra	32.0	7.0	2.0	14.0	34.0	0.0	4.0	7.0	0.8	8568
Connie	36.0	0.0	6.0	13.0	16.0	0.0	21.0	0.0	9.0	1569
Kala	23.0	25.0	3.0	0.2	27.0	0.0	16.0	3.0	3.0	1962
Khun-Chorn	13.30	0.0	10.7	0.0	27.0	0.0	33.0	0.0	16.0	308
Minyahk	24.0	0.0	4.0	18.0	23.0	0.0	2.01	28.0	2.0	2927
Moola	26.0	0.0	0.0	32.0	23.0	0.0	7.0	12.0	0.0	786
Onyx	0.6	0.0	6.0	59.0	4.0	0.0	1.0	15.0	14.0	1555
Patience	33.0	0.0	9.0	5.0	44.0	0.0	0.0	0.0	10.0	1147

Percent Submissive and Aggressive Behaviors of Elephants in Their Play Groups

Asha was 53.0% SB and 47.0% AB in group with CH and MI. CH was 50.0% SB and 50.0% AB while in the same group. MI had 45.0% SB and 47.0% AG when with Asha and CH. CI had 70.0% SB when with O and MO but exhibited 21. 0% SB and 9.0% AB when with C and O. C demonstrated 29.0% AG and 5.0% SB when with P & K; but with O and CI she had 24.0% SB and 12.0% B. When with MI and MO C exhibited 14.0% SB and 16% AB. If K was only with P, he presented 3.0% SB, and no AB; when C was with them, 24.0% SB and 55.0% AB; and if MO was with them, 6.0% (SB) and 15.0% AB.

KC displayed 54.0% SB and 46.0% AB while he played. When MI was with MO and C, she used 2.0% SB and 8.0% AB. MO exhibited 23.0% SB and 14.0% AB when with P and K; and when she was with C and MI, 2.0% SB and 30.0% AB. During the time she spent with O and CI, there was 4.0% SB and no AG. When O was by himself, he exhibited 13.0% SB & 15.0% AB. When he was with MO and CI, he presented 53.0% SB and no AB. During his time with C and CI, there was 17.0% SB and 2.0% AB. P did not exhibit SB and AB when she was only with K but if with MO, she used 47.0% SB and 20% AB, and when with C, 21% SB and 13% AB (Figure 16, Table 16) .

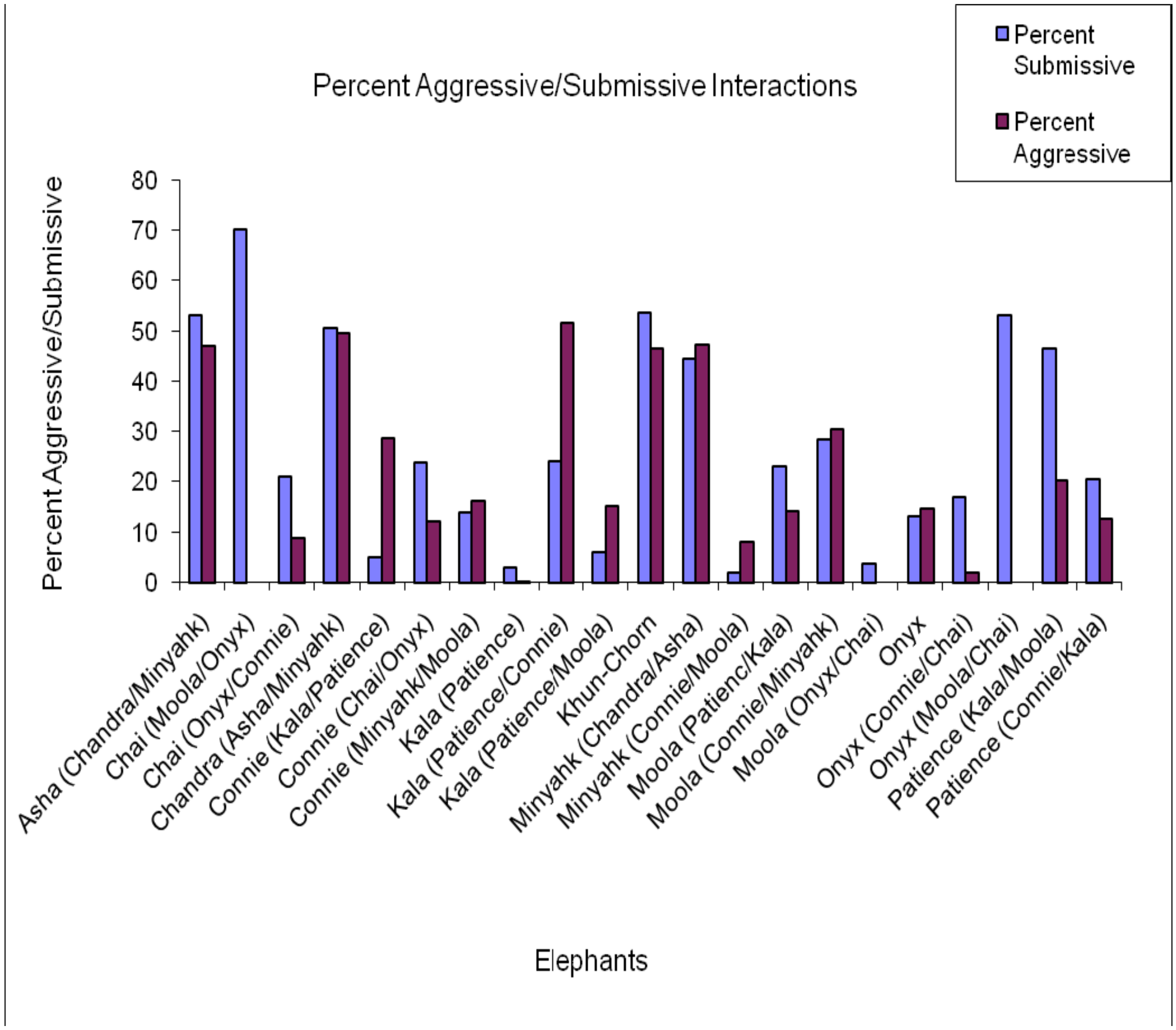


Figure 16. Percent Submissive and Aggressive Behaviors Displayed within Play Groups by Individual Elephants .

Table 16. Percent Submissive and Aggressive Behavior of Elephants in their Play Groups

Elephants	Total Submissive/Aggressive (min)	Percent Submissive	Percent Aggressive
Asha (Chandra/Minyahk)	6974	53.0	47.0
Chai (Moola/Onyx)	1404	70.0	0.0
Chai (Onyx/Connie)	1404	21.0	9.0
Chandra (Asha/Minyahk)	8568	51.0	50.0
Connie (Kala/Patience)	1569	5.0	29.0
Connie (Chai/Onyx)	1569	24.0	12.0
Connie (Minyahk/Moola)	1569	14.0	16.0
Kala (Patience)	1962	3.0	0.2
Kala (Patience/Connie)	1962	24.0	52.0
Kala (Patience/Moola)	1962	6.0	15.0
Khun-Chorn	308	54.0	46.0
Minyahk (Chandra/Asha)	2927	44.0	47.0
Minyahk (Connie/Moola)	2927	2.0	8.0
Moola (Patienc/Kala)	786	23.0	14.0
Moola (Connie/Minyahk)	786	29.0	30.0
Moola (Onyx/Chai)	786	4.0	0.0
Onyx	1555	13.0	15.0
Onyx (Connie/Chai)	1555	17.0	2.0
Onyx (Moola/Chai)	1555	53.0	0.0
Patience (Kala/Moola)	1147	46.0	20.0
Patience (Connie/Kala)	1147	21.0	13.0

Reproductive Status

Percent Play While at Different Reproductive Status

One hundred percent of male play was done out of Musth because there were no Musth episodes during this study. CI was Pregnant 0.34% of the study and 28.0% of female play was done while they were in Estrus; 53.0 % of female play was done while they were in Non-estrus, and 18.0% of the study was done with MI who has Irregular cycles (Figure 17, Table 17).

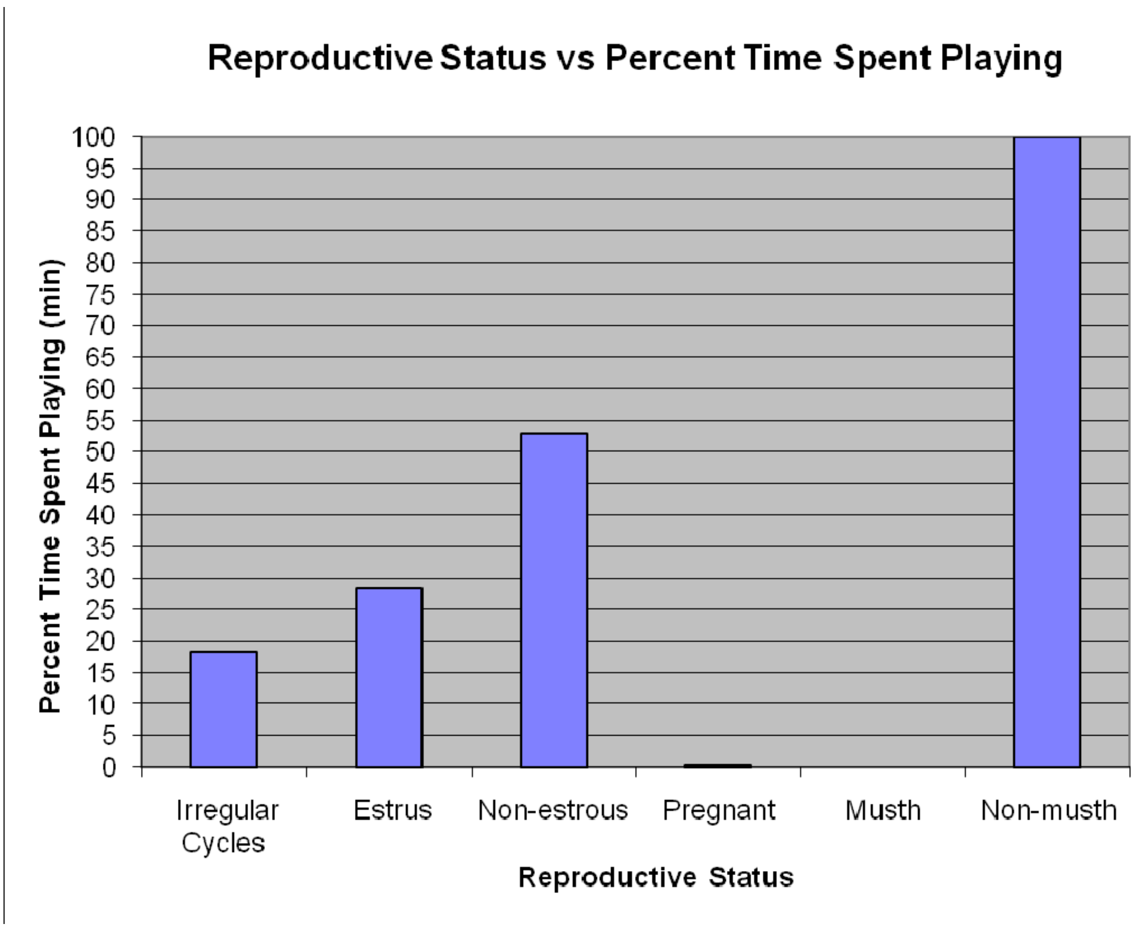


Figure 17. Percent of Time Spent Playing While Elephants are in Differing Reproductive Status.

Table 17. Percent Play while at Differing Reproductive Status

	Irregular Cycles	Estrus	Non-estrous	Pregnant	Musth	Non-musth
Percent Time Spent Playing	18.0	28.0	53.0	0.3	0	100

Percent Time Spent Playing in Different Reproductive Status

During this study MI was in 93.0 % Irregular cycles, 2.0% Estrus, and 5.0%.Non-estrus. C, P, and MO were Estrus 100% of the time. All of the males were in Non-Musth 100% of the time. There were no Musth episodes during the course of the study. All of CH's play was done in Non-estrus. CI was in Estrus 84.0% of the time and 16% while Pregnant. Asha was in Estrus 18% of the time and 82% in Non -estrus. Asha had her first heat cycle during this study; 18% of her play was in Estrus, the rest in Non- estrus (Figure 18, Table 18).

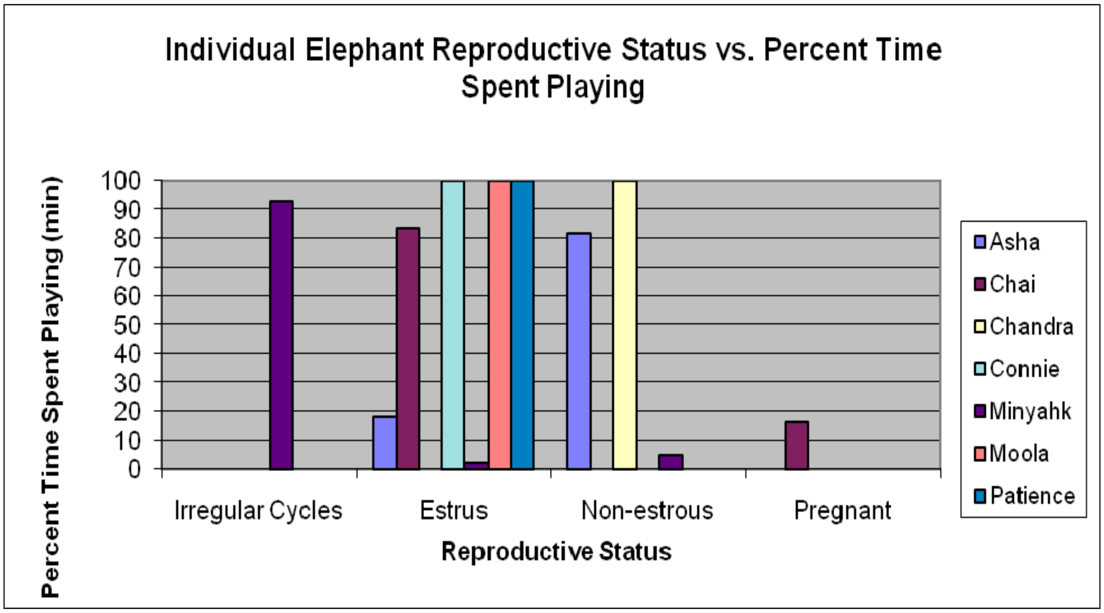


Figure 18. Percent Play When Individual Elephants are in Differing Reproductive Status.

Table 18. Percent Time Spent Playing in Different Reproductive Status

Elephant'S Name	Percent Play Irregular Cycles	Percent Play Estrus	Percent Play Non-estrous	Percent Play Pregnant	Percent Play Musth	Percent Play Non-musth
Asha	0.0	18.0	82.0	0.0	0.0	0.0
Chai	0.0	84.0	0.0	16.0	0.0	0.0
Chandra	0.0	0.0	100	0.0	0.0	0.0
Connie	0.0	100	0.0	0.0	0.0	0.0
Minyahk	93.0	2.0	5.0	0.0	0.0	0.0
Moola	0.0	100	0.0	0.0	0.0	0.0
Patience	0.0	100	0.0	0.0	0.0	0.0
Kala	0.0	0.0	0.0	0.0	0.0	100
Khun-Chorn	0.0	0.0	0.0	0.0	0.0	100
Onyx	0.0	0.0	0.0	0.0	0.0	100

Inside/Outside Play

Percent Total Time Spent Playing Inside and

Outside According to Gender

Female percent of play Inside was 29.0% and Outside was 31.0%. Males Inside play was 3.0%, while their Outside play was 27.0 %.(Table 19, Figure 19)

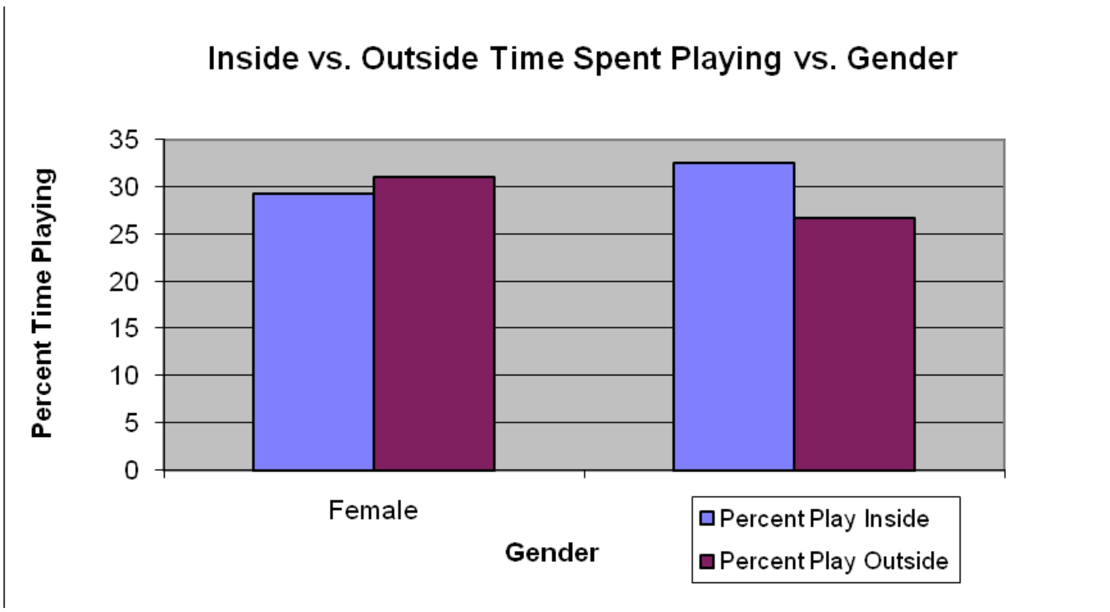


Figure 19. Percent of Time Elephants Spent Playing Inside and Outside According to Gender.

Table 19. Percent Total Time Spent Playing Inside and Outside According to Gender

Gender	Total Play Inside (min)	Total Play Outside (min)	Total Time Inside (min)	Total Time Outside(min)	Percent Play Inside	Percent Play Outside
Female	93370	100042	318420	322380	29.0	31.0
Male	26866	21016	82680	78660	33.0	27.0

Percent of Total Time Played Inside and Outside

For Each Elephant

Asha played Outside (O) 45.0% of the time and Inside (I) 25.0%. CH played 35.0% Inside and 29.0% Outside. CI spent about the same in both locations, at 26.0% Inside and 28.0% Outside. C played 42.0% of the time Inside and 29.0% Outside. K did 34.0% of his play Inside and 34.0% Outside, while KC played Inside 26.0% of the time and Outside 23.0% . MI spent 26.0% of her playtime Inside and 23.0% Outside. MO preferred to play Inside 38.0% of the time and Outside 29.0%. O spent 31.0 % of his play time Inside and 24% Outside. P was Inside 28.0% to play and 15.0% Outside (Figure 20, Table 20).

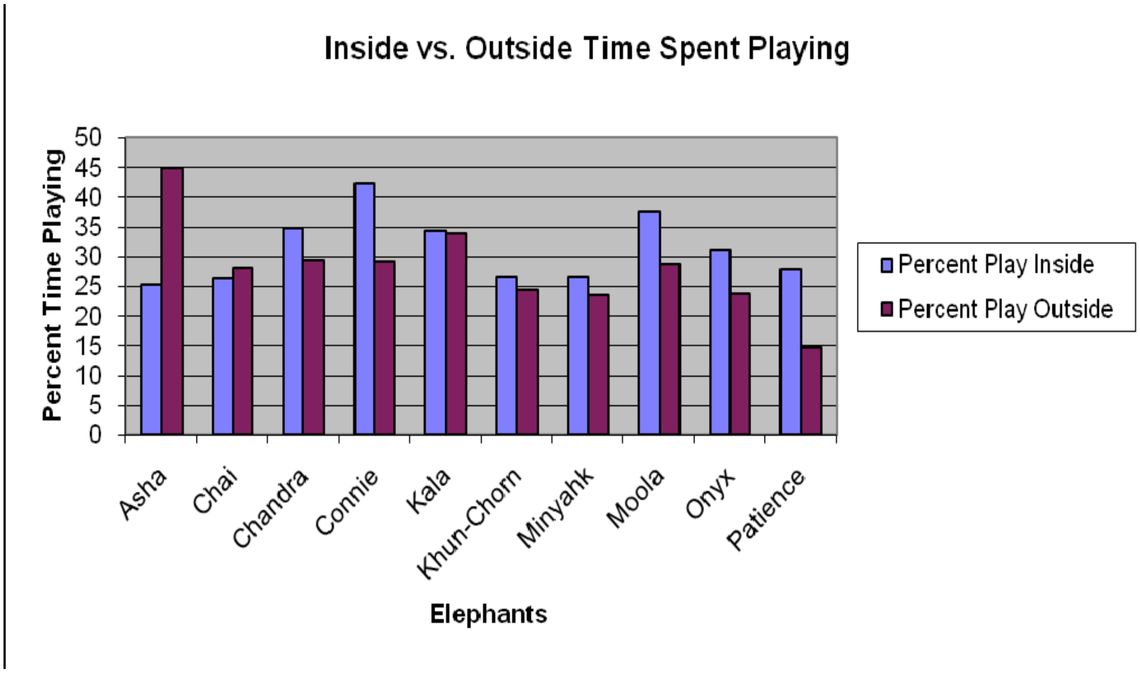


Figure 20. Percent of Total Play Inside and Outside for Each Elephant (Table 20).

Table 20. Percent of Total Time Played Inside and Outside for Each Elephant

Elephant's Name	Total Time Inside (min)	Total Time Outside(min)	Total Time (min)	Total Play Inside (min)	Total Play Outside (min)	Percent Play Inside	Percent Play Outside
Asha	97260	80940	178200	24549	36280	25.0	45.0
Chai	1080	13140	14220	284	3673	26.0	28.0
Chandra	89880	74640	91378	31149	21849	35.0	29.0
Connie	11940	33060	45000	5038	9621	42.0	29.0
Kala	54000	21660	75660	18484	7314	34.0	34.0
Khun-Chorn	11040	31320	42360	2921	7615	27.0	24.0
Minyahk	72540	74100	146640	19179	17413	26.0	24.0
Moola	5040	31200	36240	1895	8948	38.0	29.0
Onyx	17640	25680	43320	5461	6087	31.0	24.0
Patience	40680	15300	55980	11276	2258	28.0	15.0

CHAPTER VIII

DISCUSSION

Chapter Rational

Chapter VIII discusses the results of this study and offers our conclusions.

Introduction

Play has primarily been thought of as an activity of young mammals and to some extent an avian phenomenon. However, with new research on different classes of vertebrates and invertebrates, we are finding that many animals play. Invertebrates are not thought of as a particularly playful group of animals but class Mollusca: Cephalopoda (octopus) seems to be the exception.

Vertebrates and invertebrates separated 1,200 million years ago (Wray, *et al.* 1996). The importance of determining that octopuses play is that if they play, play behavior has evolved twice (it evolved in vertebrates and in cephalopod mollusca) (Mather & Anderson, 1999) and that play evolved in an animal which occupies such different surroundings. Mather and Anderson (1999) work was based on Mather's earlier study in which juvenile octopuses chose particular localities for shelters. They made modifications (getting rid of rocks and sand from inside and selecting certain articles to put in front of the entrances) to the shelters. Shelter entrances were inclined to face horizontally and away from shore, and they were repeatedly situated just below mean low tide level. Octopuses brought significantly more rocks to block the aperture when it was larger (r=0.686). Both larger home volume and the presence of preferred prey predicted longer duration of stay in shelters (Mather, 1994). She concludes that such behavior illustrates signs of both intelligence and tool use (Mather, 1994). This finding was the foundation of Mather and Anderson's study on exploration and play in octopuses *Octopus dofleini*. They found that the octopus exhibited exploratory play which was made up of aiming water jets through the flexible funnel, which would cause the expected transfer of an object to and then returned by the aquarium intake current (Mather & Anderson, 1999). They encouraged other researchers to be open to the possibilities of animals that are capable of complex behaviors. The function of play must have far reaching benefits if it is found in animals as distinct from the vertebrates as the octopus.

It is generally accepted that play is not an evolved behavior in reptiles because of its high energy cost versus its benefit. Endoderms generate energy more efficiently than do ectoderms. As they evolved, their efficient energy production allowed young the energy to sharpen adult behaviors through play. No doubt this gave juveniles an advantage for survival, making the cost in energy worth the expense (except when there was hardship in which case play and exploration were reduced if not eliminated). This was not the case for reptiles, so it has been assumed they did not play.

Burghart and colleagues (1996) observed that the captive Nile soft-shelled turtle at the National Zoo spent time interacting with objects, so they investigated this behavior

The results were that the turtle interacted with the objects they gave it (basketball, hose, stick etc.) for 21.0% of the time it was observed and that it was active 68.0% of the time. These results were high for any animal (most of all a turtle). They summed up their results as, "The existence of vigorous play like behavior in a member of an ancient reptilian lineage indicates that, in the right circumstances, object play can be performed by reptiles and that having the opportunity to do so may be beneficial in captivity (Burghardt, *et al.,* 1996).

An interesting account of birds at play is the 2002 article of Gamble and Cristol. For three years they observed herring gulls, *Larus argentatu*, repeatedly dropping and catching objects. They speculated that their behavior may be play behavior or possibly serve another function like exposing kleptoparasites or repositioning clams before the gulls scavenged them. They determined that the gulls were playing and that the behavior was engaged in mostly by younger birds, not always over hard surfaces and that sometimes the objects that were dropped and were not food items. Consistent with play, 1. the younger gulls play- dropped more objects than the older birds; 2. drop play was done over soft surfaces rather than the hard surfaces of foraging areas, and 3.the drop play was done with all manner of objects, so foraging was not the purpose for the play. Birds do play and in the next example, they include an unlikely companion.

Ravens are primarily scavengers that consistently follow packs of wolves from kill to kill, joining in on feeding off the carcass and often eating droppings from the wolves (Coprophagy). Sometimes they fly in circles overhead while the wolf pack makes their kill (Mech, 1970). Crisler (1958) describes an observation she made between her free-ranging wolf pups and a raven as follows: "He (the raven) let the pups trot to within six feet of him, then rose and settled a few feet away to await them again. He played this raven tag for ten minutes at a time. If the wolves ever tired of it, he sat squawking till they came over to him again." Both the wolf and raven have highly evolved social systems and have the psychological mechanism needed to form social attachments. It is possible that individuals from each species have incorporated members of the other species into their social groups, much like wolves form social bonds with humans when they are raised by them (Mech, 1970). It seems that wolves and raven have formed a symbiotic relationship which includes play, each one benefiting. Whether on wing, paw or hoof, animals play according to specific characteristics, and ungulates are no exception.

In ungulate play, there is a distribution of play motor patterns which extends across family lines. They imply that locomotor play mimics flight behaviors first and then solitary locomotor-rotational play (Power, 2000). In ungulates, social play takes place as a coordinated herd activity that strongly involves adults. The highly social nature of ungulates implies that this type of play has been modified to promote group cohesion. Studies show that equid play (McDonnell & Poulin, 2002) as well as play in dairy calves (Jensen, *et al.*, 1998) follows this sequence of behaviors.

Elephants at Play

Until 1992 enrichment for elephants was food- hiding or providing novel food items (Schanberger, *et al.*1992). Enhancing the opportunity for species-specific behavioral enrichment in captive animals is a high priority, according to the AZA, especially in regard to endangered species (Shepherdson, 1992; Rice, 1998; Savage, 1993). As previously stated enrichment is a primary strategy in motivating natural behaviors and is a useful tool in reducing the stress load believed to inhibit reproduction (Carlstead & Sheoherdson, 1994; Lindburg, & Fitch-Snyder, 1994; Priest, 1991). Elephants are not only intelligent and curious, they also possess a “sense of humor” (Carden, personal observation & communication; Bekoff, 2003). Therefore, to encourage play by providing them “toys” may ultimately prove to develop their sense of well-being and thereby improve the possibility of proper breeding behavior (Carlstead & Shepherdson, 1994). North America’s elephants are destined to live out their lives in captivity. At this time there is no “wild” place left for them. African and Asian elephants have been evolutionarily successful because they are highly adaptable while other members of the order Proboscidea went extinct. One of the goals of institutions housing them is to create a natural setting within the confines of their borders, which will offer a more stress free environment (Leach, 1993). Toys can offer an opportunity for the stimulation of natural behaviors, problem solving, and stimulation of senses, and can encourage interaction between individuals and produce pleasure, resulting in a sense of well-being (Bekoff, 2001).

Discussion of Study Categories

Age

The Infant (0-1), and the Juveniles (1-12) both spent 47.0% of observed time playing, and the adolescent (13-20) spent more time playing than any other age category (51.0%). Elephants at 0 to 20 years played more than the others. This is in keeping with the idea that the young play more than adults. Onyx, the Middle Adult male, played

51.0% of the time, which was 3.0% more than the infant male. This is contrary to accepted theory that the young play more. A possible explanation for this anomaly is that Onyx was in with Chai for breeding during most of the study. The Blowing, (7.0%), Mouthing (3.0%), Smelling (5.0%), and Tusking (3.0%) were done when he was alone and possibly frustrated because of his heightened state of arousal.

Exploration and play are both a part of a healthy young animal's introduction into its environment and could mean the difference between life and death for those in their natural habitat. Even though they are playing, it is important they get the pattern correct. This is not necessarily true for young captive animals. Though it is not a case of physical survival for them it is an instance of their, observing species- specific behaviors that unite with others of their breed. Fulfilling those innate behaviors brings a sense of well-being in itself.

<u>Vocalizations</u>

Communication is a vital part of elephant life (Poole, 1999; Payne, 2003). Elephants use chemo- communication (Leach, *et al.* 1998 Rasmussen, 1999), infrasound (Payne, 1997; Langbauer, 2000) and audible sound equally. We were only able to monitor audible sound.

Of the 60 audible sounds produced throughout the study 36 were Chirps and of the 36 Chirps, 23 of them came from Minyahk (Middle Adult, female, matriarch) while she was playing with the two Juvenile females, Asha and Chandra. Chirps indicate pleasurable excitement and /or greeting. In this situation the older female, communicates this message to the younger females who may have been apprehensive about the introduction of the enrichment item. With Minyahk reassurance, Asha and Chandra are comfortable to explore the device.

In elephant society, Minyahk was allomothering, a form of cooperative behavior where females of the herd watch over the young (Lee, 1987; Schulte, 2000). In the wild, females (other than the mother) care for and protect calves from predators as well as instruct them in the ways of being an elephant (for example, what, where, and how to eat, or how to make their unruly trunks behave). Although captive elephants do not experience most of the dangers of the wild, but the young still need the comfort and coaching of an older, more experienced adult. In elephant society, the young are of prime importance and their creed is "it takes a herd to raise a calf ". There were 3 audible vocalizations from the males, two Chirps made by Onyx and one by the infant male, Kala. This is consistent with males not being as communicative as females) (Langbauer, 2000). Males live solitary life styles and the only communications they usually exercise are those that convey a warning to other males (trumpets and roars) and those that help locate a female in estrus (rumbles). Females live in highly complex social systems which require them to be in touch with one another constantly (Shoshani, & Eisenberg, 1982; Sukumar, 1991; Pool, *et al.*, 1997).

The female who made the second most vocalizations was Connie (Middle Adult, becoming the next matriarch). She used 5 roars and 5 rumbles. Rumbles were utilized only with Kala and his mother, Patience (Young Adult). Patience also made 3 roars when Connie was present and 3 when she was with Kala alone. Rumbles are the higher frequency (which humans can hear) of a largely infrasonic vocalization. Females use infrasound continually. Rumbles are attention getters; they emphasize and call attention to the importance of the communication. Connie is moving up into matriarch position and is influencing a very active infant bull. His mother is also using rumbles in the same manner.

Time Spent With Enrichment Items

Males played 48.0% of the observed time, as did females. This agrees with the suggestion that both genders play the same amount of time but do not always engage in the same type of behaviors (Fagen, 1981; Burghardt, 2005). Males use play fighting and activities that physically pit them against another male. These behaviors encourage practice fighting and establishing dominance or rank. Other males play practice hunting prey or avoiding predators or a combination of both (Beckoff, & Byers, 1981; Siviy, 1998; Bekoff, 2001). Elephants respect strength, so when the young males play they push on each other, applying their mass against their play opponent to physically move them. They also play fight using their trunks, mouths, and developing tusks (if they are going to have them). Not all Asian male elephants develop tusks, but those that do definitely have an advantage when fighting or sparing.

Female play tends to mimic food gathering and honing needed social skills that are required in their particular social system. Female cougars live a solitary life except for the short time they have young. During that time they teach their young how to be a cougar (hunting, establishing and defending a territory, mating practices, etc.). Female elephants being decidedly social have complex interactions with subtle nuances that must be mastered by young females. Play between females and males are usually characterized by mating displays or behaviors and play chasing. Other species in close proximity are fair game for being chased; even the fierce water buffalo run and scatter when the object of their game. The young play under the close scrutiny of the watchful eyes of their nannies, which other animals seem to sense.

There were no differences in enrichment item choice or how the item was manipulated between male and females.

The enrichment item preferred by all elephants was Browse. Having Browse is definitely enriching for the elephants but not suitable for a play study. Play should not have a reward except for the activity itself. Browse is a food item that is pleasurable to consume and fulfills an animal's hunger as well as nutritional needs. This is not play. The other enrichment item that was not satisfactory was the Pin Wheel. It was offered to the group composed of Minyahk, Asha, and Chandra only and clearly was not their favorite. It proved to be an unsafe device because it could not hold up to the rigorous physical inquiries of these three elephants.

The remaining 3 enrichment items are good examples of devices that elicit play behavior. Overall preferences among the items were the Fiddle Chain (20.0%), Tire (17.0%), and Chimes (15.0%). An Elephant's individual preference for a certain item was more apparent among these three. Chimes were favored by Asha (20.0%), Chai (16.0%), and Moola (18.0%). The sound they made was more melodic than cranky. The Fiddle Chain was used the most by Minyahk (16.0%), Chandra (23.0%), Connie (37.0%), and Onyx (19.0%). Kala (33.0%), Khun-Chorn (35.0%), and Patience (26.0%) played most with the Tire . It is apparent that the degree of preference varies.

When Patience and Kala were together their interest in Browse was 45.0% P and 30.0%K. Their interest fell off to nothing when Moola was with them and to 6.0 % (P) and 9% (K) when Connie was there. During the same play time, Moola's interest in Browse was 0% and when Connie was there her interest was 8.0%.. The Fiddle Chain and Tire were the only enrichment items used when the group was Moola, Patience and Kala or Connie, Patience, and Kala. The only times that Moola and Connie played with the Fiddle Chain were when they were with Kala and Patience. Patience did not play with anything except Browse when she was with just Kala. The same was true of Kala. He was most interested in playing with the Tire and Fiddle Chain when he was with a female other than his mom and only in Browse when with her. It took the stimulation of the other females to entice him into play. Connie and Moola appeared to be teaching/encouraging him to explore and play.

In the group with Minyahk, Asha, and Chandra, Asha and Chandra's play behavior mirrored one another, which may be an effect of allowmothering. Not only do the adult females carry out this responsibility, but it is often done by juvenile females like Asha. This prepares them for motherhood and being a productive member of their society. Asha was almost 3 years older than Chandra and would influence Chandra's play. They both experienced all of the enrichment items, as did Minyahk. Her play with the two juvenile females was the only time she used anything except Browse.

Interest in the individual enrichment items varied from elephant to elephant. When Minyahk was with Asha and Chandra, she was actively playing for their edification but when she was with Connie and Moola, her only play was with the Chimes 3.0% and Browse (9.0%). Connie, Moola, and Minyahk were only interested in play when they were with the young. This holds true of highly social animals.

Play Behaviors

Manipulations (Figure 53)

% time spent by all the elephants in each behavior

64% of time spent playing was using	trunk
15%	mouthing
13 %	using foot
4%	using head
1.6%	smelling
Less than 1%	striking and blowing

The purpose of having enrichment items was to encourage captive elephants to use their bodies and minds in a manner that imitates natural behaviors. These seven categories represent those manipulations normally implemented by elephants when encountering an object of interest. It would have been useful if both the initial and the following manipulation has been were recorded. The elephant's trunk is its greatest information gathering apparatus so it is understandable that experienced elephants would use it first and then perhaps use another behavior. Because of their naïveté, young animals use more unconventional manipulations for first contact with an out -of –the-ordinary item. For example, Kala's first encounter with the Tire was not to examine it with his Trunk but to rub his Head all over it.   He lacked experience for sure, but he also lacked expertise in exploiting his uncontrollable trunk.

An interesting fact is that when a calf is born its trunk is an unruly mass of 140,000 muscles that have no clear directions concerning how to function. Often the calf has no idea of how to make its trunk perform needed tasks. The first job a trunk has is to get out of the way when the calf nurses and that is not as simple as it sounds (see supplemental file, Figure 40). Next the young ones have to learn to drink through it, eat with it, smell through it, pick things up with it, and push or smack with it. They eventually master these skills, but not without much instruction by adults and a lot of practice on their part.

Data illustrated how enrichment items were manipulated according to the age of individual; as elephants mature unconventional manipulations decrease. Kala (Infant, 0-1) spent 29.0% of the time using Foot, 14.0% using Head, 11.0% Mouthing, and 43.0% using the Trunk. The first three behaviors are unusual, probably because he is an Infant and is learning how to use his body. Chandra (Juvenile, 1-12, and the next youngest) used her Foot 12.0% of the time, Head 5.0%, mouth 17.0% and Trunk 65.0% . Asha (Juvenile, 3 years Chandra's elder) manipulated using her Foot 16.0% of the time, Head 4.0%, Mouthing 17.0% and Trunk 62.0% of the time. Moola (Adolescent, 13-20) used her Foot 3.0%, 2.0% Head, 13.0% Mouthing, and the Trunk, 78.0% using Trunk. As the age increases, the unconventional manipulations decrease as the individual gains life experience. An interesting behavior was Connie (Middle Adult, 31-60), who used her Foot 12.0% of the time she was with Kala. Possibly this interaction between Connie and Kala was instructional play.

Another age- related behavior was that the Young Adults (20-30) used only three types of manipulations. Patience (Young Adult) used her Foot 10 % the time, Smelling 6.0% and Trunk 85.0%. Khun-Chorn (Young Adult) used Foot 15.0%, Striking 2.0% and Trunk 84.0%. Chai (Young Adult) used Foot 3%, Smelling 18%, and Trunk 79%. All three used their Foot and Trunk; two of them used Smell as their third manipulation and the other Strike. Possible implications are be that their behaviors for confronting the unusual, though appropriate, were not very flexible.

Chai was brought to Dickerson Park Zoo to be bred to Onyx, so this may account for her dependence on smell (18.0%, more than any of the others) when encountering a novel object. She had been moved to a strange place and was living among strangers, and with a male to boot. Most female elephants have never seen a male, much less been in an enclosure with one. Elephants are intended to live in a stable herd of females, most of them relatives. Here she is by herself and appears to be indicates a very submissive, tentative individual.

Onyx (Middle Adult) did the most Blowing of any elephant, 7.0%; 3.0% Mouthing, 8.0% Smelling, 78.0 % Trunk, and 3.0% Tusking when he was alone and 2.0 % Smelling when he was with Chai. His smelling when he was with Chai was more involved with breeding than play. His object play at this point was minimal. Chai's Smelling (18.0%) had a lot to do with her circumstances more than anything else . If in a strange place, an elephant is most dependent on its sense of smell to tell it about its surroundings and the animals in it. Onyx was second in the use of Smelling at 8.0%, mostly because of mating.

<u>Reproductive Status</u>

During the course of this study, only three of the elephants changed reproductive phases. Connie, Moola, and Patience were in Estrus the whole time. Chandra was too young to cycle, so she was in Non- Estrus and Minyahk was in the Irregular Cycle category for 93.0% of the time. There were no episodes of Musth during this study, so all of the males were classified as Non- Musth. Chai was in Estrus for 84% of the study and pregnant 16.0%. Asha was in Estrus 18.0% of the time and Non- Estrus 82.0%. Reproductive Status was not a decisive influence on the play behaviors of the subjects.

Musth would have had a definite effect on the results because of the highly aggressive state of the bull. The bull's behavior is often violent and directed towards humans as well as objects. Kala is an Infant and would not be expected to come into musth until he was 14 to 16 years old (Lincoln, & Ratnasoriya, 1996; Hildebrandt, *et al.*, 1998; Duer, 2004). Onyx (Middle Adult) and Khun-Chorn (Young Adult) had been in Musth many times.

Aggressive/Submissive

Submissive Behaviors: Defecation, Present Rear, Retreat, Urination.
Aggressive Behaviors: Approach, Charge, Throwing, Strike, Tushing/Tusking

Males used the behavior designated as Aggressive 45.0% of the time and Submissive Behavior 55.0% of time while playing. Females were Aggressive 43.0% of the time they were playing and Submissive 57.0% of time with a 14.0% difference. There is not a noticeable difference between females and males as far as whether they play Aggressively or Submissively.

Females used both Approach AB and Retreat SB more than males. Males used Charge, Strike AB and Defecation, Present Rear, and Urination SB more than females. Present Rear is an act of submission in which the Submissive elephant backs up to the object of its acquiescence. It could be either an object or another elephant. The 163 Present Rears in this study, 67.0% were to other elephants and 33% to objects (enrichment items). Chai used Present Rear 22 times, which again is related to her new surroundings and companion and how they have affected her behavior. Females who know how elephants behave use Present Rear to the male as a sign of submission. When the female is not aware of this sign or refuses to be submissive and show him this respect, the situation can become tenuous.

Having said that, there was an unexpected outcome in the group consisting of Onyx, Chai, and Moola. There were 157 Present Rears; 53 of them were to objects and 104 were to another elephant. As stated before, Presenting Rear is a Submissive behavior. Within that group Onyx Presented Rear 25 times, Chai 22 times, and Moola 7. It is a natural behavior for Moola and Chai but highly unusual for Onyx.

Connie played more aggressively 14.0% of the time, Kala 34.0%, and Minyahk 6.0%. These results could be expected. Kala was an infant. He was exuberant, uncoordinated, and had no idea of how to play so his behavior looked Aggressive. Connie and Minyahk are both females who play, when with the young elephants, so they need to be firm and assertive with them. The other elephants were submissive to varying degrees. Chai exhibited extreme submission; her 96.0% Submissive behavior is a direct result of her circumstances (described earlier). The rest of the elephants used varying degrees of Submissive Behaviors, which is what you would expect since all play by definition is supposed to be a positive experience that brings a sense of well-being.

Aggressive and Submissive Behaviors did not impact the results of the study. The only time behavior which could appear to be aggression is considered as play is in play fighting. It is often mistaken for true fighting but is actually play.

Inside/Outside Play

Females played Outside OS 31.0% of their time spent playing and 29.0% Inside IS. Males spent 27.0% of their play time OS and 33.0% 63. Females spent 4.0% more time playing OS than did males and males spent 4.0% more time playing IS than did the females. There are no clear preferences for play OS or IS by females or males.

The preference for play location with Patience was 13.0% more time OS than IS and also Asha spent 20.0% more time OS more than IS. Connie spent 13.0% more time playing IS than OS. Other elephants were not quite as particular where they played. Moola preferred IS play (9.0%), as did Onyx (7.0%), and Chandra (6.0%) more of the time. For some location was not an issue: Minyahk (3.0%), KC (2.0%), Chai (2.0%0) and Kala (0.0%) with differences.

Proper placement of place enrichment items is dependent on a number of factors. First, items should be in a safe, comfortable setting with enough space available for the elephants to experience play with the object and interaction with one another. Second, the individuals in the play groups should be compatible with each other because play should increase well-being and be filled with positive interactions. Third, enrichment items must be safe first, but should also be appealing to their senses and elicit natural body movement. Providing such items takes being familiar with the elephants and facility. Lastly, in most parts of the country, weather is an important matter. Most institutions have policies in place concerning temperature restrictions on when it is feasible for elephants to go outside. Both cold and heat are an issue. This study shows that individuals have varying degrees of preference for IS or OS. This variable had no influence on the results of this study.

Future Enrichment

Animal play has become a fashionable topic. With increasing numbers of family pets and the emphasis now placed on environmental enrichment for captive animals, play has been promoted as a viable form of behavioral enrichment. This trend has given the AZA a stronger commitment to enriching captive animals' well-being.

More and more studies like this one provide keepers necessary information to create innovative and stimulating enrichment opportunities for captive animals. Elephants present their own set of unique problems, but they also respond and adapt to novel situations quickly, which makes them good candidates for play enrichment (Rees, 2003).

If I were in a position right now to propose an enrichment project, I would suggest a very large pool or pond to allow the elephants to swim. Most pools installed by zoos are small and never work right, but if properly designed and constructed a pool would provide them with years of enjoyment. I was shocked the first time I saw an elephant in the water. She moved effortlessly (see supplemental file, Figure 41). Elephants are expert swimmers and have been known to swim between islands (Johnson, 1980). I believe that a pond or large pool would encourage natural behavior, giving them more control over their environment and enhancing their well-being.

Enrichment Item Design

Keepers are required to maintain documentation of enrichment projects which they implement for the animals in their care (Schanberger, 1991). These records are examined by AZA upon request. Keepers are required to submit blueprints and a list of materials, for each item being proposed, to the zoo vet for safety evaluation and approval for utilization as an enrichment item for that particular animal.

Enrichment items for elephants should stimulate species- specific behaviors. This study showed that elephants use mainly their highly sensitive trunks to manipulate play items, in agreement with Rasmussen, & Munger (1996), and to a lesser extent their foot and mouth. Elephant's feet have interdigital glands around their nails which are highly sensitive to chemical signals and also to vibration in the ground (Lamps, *et al.* 2001; Rasmussen, 1998). Often elephants are seen with their foot hovering over an object of interest, so it is not unlikely that they use their feet in play.

In designing items, it would be wise to appeal to the elephant's strong sense of smell by using materials with interesting odors. Perhaps spices or oils would enhance the enrichment's appeal. Their other strong sense is hearing. Playback of inter- specific or intra- specific vocalizations can also be an enrichment technique applied in this situation (Wemmer, & Mishra, 1982). However, because elephants can have a vigorous response to vocalizations, it would be prudent to proceed with caution. Unless the keeper knows what a vocalization means, it is not a good idea to use playbacks. Nevertheless the sound of Chimes does work well and is enjoyed by certain individuals.

Elephants have acute senses of smell and hearing, but they also have high tactile acuity. The sense of touch is the most under- appreciated of elephant behavior. When they are together, they are constantly touching one another with their trunks. It seems they are communicating their presence or state of being to the others. When a person stands among them and their presence is accepted the elephants do the same them. Their eye sight is so bad that it may be that they are monitoring your position in space in relationship to them. Appealing to this sense could also enhance natural behaviors. The Tire and Fiddle Chain are examples of the sense of touch in enrichment items.

In most every part of our lives we have developed a social conciseness/awareness that requires us to be more humane. As a result, unlike in the past, visitors to a zoo often ask questions about the well-being of the animals and their comfort level in their environments. What better evidence of comfort and well-being than for visitors them to observe animals at play?

Play Effect

Since play behavior is the practicing of a variety of behavioral skills (Field, & Thomas, 2000) use of novel enrichment items should promote the expression of different behavior patterns and not just give the animals a series of random objects. Object play mostly involves manipulation of objects and helps develop locomotor and visual coordination. When closely observed, the underlying behavior pattern in object play often seems to mimic a common activity. For example, Polar bears take large balls into their pool and shake them vigorously up and down in the water mimicking the method they use to kill seals by shaking the air out of them.

The expression of play can be a desirable behavior because it serves as an animal welfare indicator and because the provision of enrichment items gives the animals opportunity to interact with and express some control over their environment. Control is one of the main ways environmental enrichment improves the well-being of captive animals.

In conclusion, the elephant behavior in the presence of enrichment items fit the definition of play. The young played the most. Adults of this highly social species entered into most of their play when in the company of the young. Play behaviors had no reward except the activity itself. Providing enrichment items for elephants does present an opportunity for them to use species- specific abilities to enhance the control over their environment and their well-being.

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VITA

Connie K. Duer

Candidate for the Degree of

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Thesis: FUNCTION OF PLAY AS BEHAVIORAL ENRICHMENT OF CAPTIVE ASIAN ELEPHANTS (*ELEPHAS MAXIMUS*)

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Title of Study: FUNCTION OF PLAY IN BEHAVIORAL ENRICHMENT OF CAPTIVE ASIAN ELEPHANTS (ELEPHAS MAXIMUS)

Pages in Study: 175 Candidate for the Degree of Doctor of Philosophy

Major Field: Zoology

Scope and Method of Study: This research determined if enrichment items could be used as an effective tool for stress reduction in captive Asian elephants. Subjects were 3 male and 7 female Asian elephants with an age range of 9 months to 52 years of age housed at Dickerson Park Zoo in Springfield, Missouri. Enrichment devices which required natural movement and behavior, relived stress, and promoted a sense of well-being were designed and constructed by qualified zoo personnel and included Tire, Fiddle Chain, Browse, Chimes, and Pin Wheel. Behavioral data were collected using an ethogram to assess play behavior and divided into four major behavioral categories: Play, Responses, Eating and Vocalizations. An enrichment item was placed in an enclosure for 1 hour and behavioral observations were recorded at one minute intervals when an elephant was within 3 feet of the item.

Findings and Conclusions: The enrichment items promoted play and reduced stress. Browse provided an enriching experience but did not fit within the perimeters of play. The Pin Wheel proved to be unsafe. The Fiddle Chain, Chimes, and Tire were effective as enrichment items for elephants. Six of the eight variables did influence elephant play, but Inside/Outside Play and Reproductive Status did not.

ADVISER'S APPROVAL: Dr. Charles I. Abramson